TURKISH GREENHOUSE GAS INVENTORY 1990 - 2022

National Inventory Document for submission under the United Nations Framework Convention on Climate Change

TURKISH STATISTICAL INSTITUTE

November 2024

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DISCLAIMER

Türkiye signed Paris Agreement on 22nd of April 2016 and ratified on 7th of October 2021 (published in the Official Gazette dated 07.10.2021, No. 31621) and become a party to the agreement on 10th of November 2021.

The Republic of Türkiye, on the basis of "equity, common but differentiated responsibilities and respective capabilities" as clearly and accurately recognized under the United Nations Framework Convention on Climate Change of 9 May 1992 and the Paris Agreement, and by recalling decisions 26/CP.7, 1/CP.16, 2/CP.17, 1/CP.18 and 21/CP.20 adopted by Conference of the Parties to the Convention, declares that it will implement the Paris Agreement as a developing country and within the scope of its nationally determined contribution statements, provided that the Agreement and its mechanisms do not prejudice its right to economic and social development.

EXECUTIVE SUMMARY

ES.1 Background Information on Greenhouse Gas Inventories

The United Nations Framework Convention on Climate Change (UNFCCC) is an international treaty established in 1992 to cooperatively address climate change issues. The ultimate objective of the UNFCCC is to stabilize atmospheric greenhouse gas (GHG) concentrations at a level that would prevent dangerous interference with the climate system. Türkiye ratified the UNFCCC in May 2004.

To achieve its objective and implement its provisions, the UNFCCC lays out several guiding principles and commitments. Specifically, Articles 4 and 12 commit all Parties to develop, periodically update, publish and make available to the COP their national inventories of anthropogenic emissions by sources and removals by sinks of all GHGs not controlled by the Montreal Protocol.

National inventory of Türkiye is prepared and submitted annually to the UNFCCC by April 15 of each year, in accordance with revised Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories (UNFCCC Reporting Guidelines). The annual inventory submission consists of the National Inventory Document (NID) and the Common Reporting Tables (CRT) tables.

Türkiye, as an Annex I party to the United Nations Framework Convention on Climate Change (UNFCCC), reports annually on greenhouse gas (GHG) inventories. This National Inventory Document (NID) contains national GHG emission/removal estimates for the period of 1990-2022.

Pursuant to the modalities, procedures, and guidelines in Decision 18/CMA.1, parties are required to prepare and submit annual national inventory reports that provide detailed and complete information on the preparation process of GHG inventories. These reports aim to ensure the transparency, accuracy, consistency, comparability, and completeness of the inventories supporting the independent review process.

Türkiye submits a National Inventory Document (NID) along with the Common Reporting Tables (CRT) in line with the requirements of Decision 18/CMA.1 in compliance with 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

The annual GHG inventory provides information on the trends in national GHG emissions and removals since 1990. This information is essential for the planning and monitoring of climate policies.

Turkish Statistical Institute (TurkStat) is the responsible agency for compiling the National GHG Inventory. GHG inventory of Türkiye is prepared by "GHG Emissions Inventory Working Group" which is set up by the decision of the Coordination Board on Climate Change (CBCC). TurkStat is the responsible organization for the coordination of working group (WG). Moreover, TurkStat has been designated as the National inventory focal point of Türkiye by the decision taken by CBCC in 2009.

The Official Statistics Programme (OSP), based on the Statistics Law of Türkiye No. 5429 and Presidential Order No. 4, has been prepared for a 5-year-period in order to determine the basic principles and standards dealing with the production and dissemination of official statistics and to produce reliable, timely, transparent and impartial data required at national and international level. The responsibility for compiling the National GHG Inventory has also been given to TurkStat by the OSP. The inventory preparation is a joint work of GHG emission inventory WG.

The main institutions involved in GHG inventory are;

- Turkish Statistical Institute (TurkStat),
- Ministry of Energy and Natural Resources (MENR),
- Ministry of Transport and Infrastructure (MoTI),
- Ministry of Environment, Urbanization and Climate Change (MoEUCC),
- Ministry of Agriculture and Forestry (MoAF).

The National GHG emissions/removals are calculated by using 2006 IPCC Guidelines. The GHG Inventory includes direct GHGs as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), fluorinated gases (F-gases); hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), nitrogen trifluoride (NF_3) and indirect GHGs as nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC), sulphur dioxide (SO_2) and ammonia (NH_3) emissions originated from energy, industrial processes and product use (IPPU), agriculture and waste. The emissions and removals from land use, land use change and forestry (LULUCF) are also included in the inventory.

ES.2 Summary of National Emission and Removal Related Trends

Total GHG emissions, excluding the LULUCF sector, were estimated to be 558.3 Mt of CO_2 equivalent (CO_2 eq.) in 2022.This represents a decrease of 13.7 Mt, or 2.4%, in emissions compared to 2021, and a 144.9% increase compared to 1990 (Table ES 1).

Table ES 1 Greenhouse gas emissions, 1990-2022

	1990	2000	2010	2015	2016	2017	2018	2019	2020	2021	2022
Total emissions (Mt CO_2 eq. excluding LULUCF)	228.0	306.4	405.3	480.1	504.1	531.1	528.1	515.6	530.2	572.0	558.3
Change compared to 1990 (%)	-	34.4	77.7	110.6	121.1	132.9	131.6	126.1	132.5	150.9	144.9
Net emissions (Mt CO_2 eq. including LULUCF)	161.6	238.2	333.2	407.2	430.4	455.1	457.7	451.3	472.5	524.1	502.2
Change compared to 1990 (%)	-	47.4	106.2	152.0	166.4	181.7	183.3	179.3	192.5	224.4	210.8

Total GHG emissions, including the LULUCF sector, were 502.2 Mt CO_2 eq. in 2022. Thus, LULUCF included total emissions decreased by 4.2% compared to 2021 emissions. There is a 210.8% increase from 1990 to 2022 (Table ES 1).

Table ES 2 Overview of GHG emissions and removals, 1990-2022

(Mt CO_2 eq.)

GHG emissions	1990	2000	2010	2015	2016	2017	2018	2019	2020	2021	2022
CO_2 (excluding LULUCF)	154.1	232.4	317.6	386.3	404.6	429.4	422.1	404.3	414.4	455.2	441.4
CO_2 (including LULUCF)	87.6	163.9	245.4	313.4	330.8	353.2	351.7	339.9	356.5	406.2	385.2
CH_4 (excluding LULUCF)	51.3	51.5	60.1	60.5	64.1	65.3	69.6	73.0	73.5	73.9	72.2
CH_4 (including LULUCF)	51.4	51.7	60.1	60.6	64.2	65.3	69.6	73.0	73.6	74.7	72.2
N_2O (excluding LULUCF)	22.2	22.0	24.4	28.6	30.5	31.5	31.6	32.9	36.1	35.9	34.3
N_2O (including LULUCF)	22.2	22.1	24.5	28.7	30.6	31.6	31.6	33.0	36.2	36.4	34.4
HFCs	NO	0.1	2.8	4.4	4.7	4.8	4.6	5.2	6.0	6.7	10.2
PFCs	0.4	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SF_6	NO	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
Total (excluding LULUCF)	228.0	306.4	405.3	480.1	504.1	531.1	528.1	515.6	530.2	572.0	558.3
Total (including LULUCF)	161.6	238.2	333.2	407.2	430.4	455.1	457.7	451.3	472.5	524.1	502.2

Note that 0.0 kt figures refer to values smaller than 0.05 but greater than zero.

Total GHG emissions as CO_2 eq. for the year 2022 were 558.3 Mt (excluding LULUCF). Overall in 2022, the Energy sector had the largest portion with a 71.8% share of total emissions. The Energy sector was followed by the sectors of Agriculture with 12.8%, IPPU with 12.5% and Waste with 2.9%. GHG emissions by sectors are presented in Table ES 3 for 1990-2022.

Table ES 3 Greenhouse gas emissions by sectors, 1990-2022

($Mt\ CO_2$ eq.)

Year	Energy	IPPU	Agriculture	LULUCF	Waste	Total (Excluding LULUCF)	Total (Including LULUCF)
1990	143.1	22.7	51.8	-66.4	10.3	228.0	161.6
1991	147.5	24.4	52.9	-67.4	10.7	235.4	168.0
1992	154.0	24.1	52.7	-67.5	11.0	241.8	174.3
1993	160.4	24.6	52.8	-66.7	11.3	249.1	182.5
1994	156.8	24.0	50.3	-68.0	11.7	242.8	174.7
1995	170.0	25.4	49.0	-67.9	12.1	256.5	188.5
1996	187.8	26.0	49.5	-67.3	12.5	275.9	208.6
1997	199.9	26.9	46.8	-70.5	13.1	286.7	216.3
1998	199.7	27.2	47.7	-70.6	13.5	288.1	217.5
1999	197.8	25.6	48.2	-71.2	14.0	285.6	214.4
2000	219.8	26.1	46.0	-68.2	14.5	306.4	238.2
2001	203.1	25.7	43.7	-70.7	15.1	287.6	216.8
2002	209.6	26.7	40.7	-69.4	15.5	292.5	223.1
2003	223.9	28.0	44.2	-71.3	16.0	312.1	240.9
2004	229.7	30.6	45.0	-69.9	16.5	321.7	251.8
2005	247.7	34.0	46.3	-72.2	16.9	344.8	272.6
2006	263.9	36.4	47.6	-71.6	17.4	365.2	293.6
2007	294.9	39.3	47.2	-71.9	17.7	399.0	327.1
2008	291.0	41.3	44.8	-67.9	17.8	394.9	327.1
2009	295.7	42.7	45.1	-70.8	17.8	401.3	330.6
2010	290.9	48.6	47.7	-72.1	18.1	405.3	333.2
2011	312.6	53.4	50.3	-75.6	18.4	434.8	359.2
2012	324.9	55.7	56.3	-73.4	18.3	455.2	381.7
2013	311.9	58.7	59.4	-76.4	17.3	447.3	370.9
2014	330.4	59.4	59.5	-76.9	17.1	466.4	389.5
2015	344.0	59.2	59.2	-72.9	17.7	480.1	407.2
2016	361.9	63.2	61.7	-73.7	17.3	504.1	430.4
2017	381.8	66.1	66.3	-76.0	16.9	531.1	455.1
2018	374.7	67.1	68.9	-70.4	17.3	528.1	457.7
2019	368.9	58.4	71.5	-64.3	16.8	515.6	451.3
2020	369.5	67.2	76.4	-57.6	17.0	530.2	472.5
2021	406.5	74.7	75.4	-47.9	15.4	572.0	524.1
2022	400.6	69.9	71.5	-56.1	16.3	558.3	502.2

IPPU: Industrial Processes and Product Use
LULUCF: Land Use, Land Use Change and Forestry

As shown in Table ES 3, emissions from energy decreased by 1.4% to 400.6 Mt CO_2 eq. in 2022 compared to 2021. However, there is a 179.8% increase compared to 1990. Emissions in the IPPU sector increased to 70 Mt CO_2 eq. in 2022 which is 6.4% lower than the emissions in 2021. Emissions in the agriculture and waste sectors were 71.5 Mt CO_2 eq. and 16.3 Mt CO_2 eq. respectively in 2022.

ES.3 Overview of Emission Estimates and Trends

In 2022, the highest portion of total CO_2 emissions originated from the Energy sector with 86.6%. The remaining 13.1% originated from IPPU, 0.3% from Agriculture and 0% from Waste. CO_2 emissions from energy decreased by 1.4% compared to 2021 while increased by 188.9% as compared to 1990. CO_2 emissions from IPPU decreased by 12.2% compared to 2021 and increased by 171.7% compared to 1990.

The largest portion of CH_4 emissions originated from Agriculture with 60.5% while a share of 19.9% is from Energy, and 19.6% from Waste and IPPU. CH_4 emissions from Agriculture decreased by 5.2% compared to 2021 and it increased by 31.6% compared to 1990. Though CH_4 emissions from waste increased by 6.1% compared to 2021, it increased by 57% compared to 1990.

While 77.9% of N_2O emissions was from Agriculture, 11.2% was from Energy, 6.2% was from Waste, and 4.6% from IPPU. There is a 4.5% decrease and 54.6% increase in total N_2O emissions compared to 2021 and 1990, respectively. GHG emissions by sectors are shown in Table ES 4.

Table ES 4 GHG emissions, 1990-2022

(kt)

Emission sources	**1990**	**2000**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
CO_2											
Total	154 141	232 351	317 555	386 322	404 648	429 350	422 146	404 301	414 378	455 248	441 423
Energy	132 343	206 908	273 010	332 251	346 060	367 847	360 174	351 890	353 470	387 950	382 368
IPPU	21 312	24 804	43 889	53 259	57 291	60 053	60 714	51 120	59 247	65 993	57 911
Agriculture	460	617	645	811	1 295	1 450	1 257	1 288	1 657	1 302	1 138
Waste	26.1	21.0	11.2	1.1	1.8	1.5	1.2	2.4	3.6	4.1	5.3
CH_4											
Total	1 831	1 840	2 145	2 162	2 289	2 331	2 485	2 606	2 625	2 640	2 577
Energy	324	379	515	303	442	369	401	496	456	519	513
IPPU	0.3	0.4	0.4	0.6	0.7	0.7	0.7	0.6	0.6	0.7	0.6
Agriculture	1 185	994	1 043	1 291	1 293	1 426	1 535	1 580	1 637	1 645	1 559
Waste	321	467	587	567	553	535	548	529	531	475	504
N_2O											
Total	83.7	83.1	92.2	108	115	119	119	124	136	136	129
Energy	6.5	8.5	13.2	12.2	13.0	13.8	12.5	12.0	12.4	15.0	14.5
IPPU	3.6	2.8	5.5	4.9	4.1	3.9	6.1	6.8	6.7	6.8	6.0
Agriculture	68.7	66.3	67.3	84.0	91.2	94.1	93.1	98.0	109	106	101
Waste	4.9	5.5	6.1	6.9	6.9	7.1	7.3	7.4	7.9	8.0	8.1

IPPU: Industrial Processes and Product Use. The LULUCF sector is not included.
Figures in the table may not add up to the totals due to rounding.

ES.4 Indirect GHG Emissions

Emissions of NO_x, CO, NMVOC, SO_X and NH_3 were also included in the report because they influence climate change indirectly. Table ES 5 shows indirect GHG emissions. 99.5% of total NO_x emissions which was 0.98 Mt, comes from Energy sector. Similary, 98.1% of total CO emissions as high as 1.56 Mt in 2022 was due to the energy sector. NMVOC emissions was 1.1 Mt in 2022. The largest portion of NMVOC emissions came from Agriculture with 42.7% which is followed by IPPU with 33.2% and almost all SO_X emissions with 2.7 Mt was from the energy sector in 2022.

Table ES 5 Indirect GHG emissions, 1990-2022

(kt)

Emission sources	1990	2000	2010	2015	2016	2017	2018	2019	2020	2021	2022
NO_x											
Total	124	1 262	979	961	993	973	959	971	956	981	983
Energy	121	1 252	976	957	989	969	955	966	951	972	978
IPPU	1.0	7.6	2.8	3.7	3.5	3.8	4.1	4.2	4.3	5.0	4.7
LULUCF	0.5	1.1	0.1	0.1	0.4	0.6	0.3	0.7	0.9	4.3	0.5
Waste	1.3	1.1	0.4	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.0
CO											
Total	886	7 660	3 333	2 366	2 353	2 194	1 660	1 749	1 910	1 890	1 593
Energy	836	7 594	3 313	2 351	2 328	2 160	1 643	1 719	1 875	1 729	1 563
IPPU	8.6	8.5	7.3	8.4	10.8	10.6	10.2	10.8	11.0	11.2	13.9
LULUCF	17.9	37.6	5.1	4.6	14.6	21.5	6.4	18.4	23.1	149	16.1
Waste	23.7	20.0	7.5	2.3	0.6	1.5	0.3	0.9	1.1	0.3	0.5
NMVOC											
Total	727	1 447	1 104	1 095	1 105	1 132	1 109	1 137	1 177	1 174	1 142
Energy	103	736	405	288	285	264	209	222	241	230	228
IPPU	252	317	328	346	351	358	362	366	369	376	380
Agriculture	355	353	332	414	419	461	487	499	516	518	488
Waste	17.2	39.8	39.4	46.3	49.3	49.0	50.3	50.5	50.5	49.4	47.1
SO_X											
Total	560	710	2 473	1 959	2 274	2 379	2 528	2 533	2 310	2 700	2 738
Energy	556	704	2 470	1 956	2 271	2 376	2 524	2 529	2 306	2 695	2 733
IPPU	3.8	5.3	2.6	3.2	3.4	3.6	3.7	3.8	4.0	4.7	5.0
Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NH_3											
Total	88.3	96.4	61.9	50.4	45.3	42.7	42.8	46.2	46.4	39.0	26.8
Energy	0.4	0.9	2.7	6.3	5.7	4.5	3.3	3.7	4.1	4.2	4.2
IPPU	5.8	3.5	4.0	4.1	3.2	3.7	5.1	6.4	6.5	7.7	4.8
Waste	82.1	91.9	55.2	40.0	36.4	34.5	34.4	36.1	35.7	27.1	17.8

Note that 0.00 kt figures refer to values smaller than 0.005 kt but greater than zero.

Figures in the table may not add up to the totals due to rounding.

IPPU: Industrial Processes and Product Use

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ABBREVIATIONS AND ACRONYMS

2006 IPCC Guidelines	2006 IPCC Guidelines for National Greenhouse Gas Inventories
ABPRS	Address Based Population Registration System
AD	Activity data
AFOLU	Agriculture, Forestry and Other Land Use
AWMS	Animal waste management systems
BCEF	Biomass conversion and expansion factor
BEF	Biomass expansion factor
BOD	Biochemical oxygen demand
BOF	Basic oxygen furnace
BOTAŞ	Petroleum Pipeline Corporation
BWD	Basic wood density
C	Carbon
°C	Degree centigrade
C_2F_6	Hexafluoroethane
$CaCO_3$	Calcium carbonate
CAGR	Compound annual growth rate
$CaMg(CO_3)_2$	Dolomite
CaO	Calcium oxide
CBCC	Coordination Board on Climate Change
CBCCA	Coordination Board on Climate Change and Adaptation
CBCCAM	Coordination Board on Climate Change and Air Management
CF	Carbon fraction of dry matter
CF	Carbon fraction
CF_4	Carbon tetrafluoride
CFCs	Chlorofluorocarbons
CH_4	Methane
CITEPA	Technical Reference Center for Air Pollution and Climate Change
CKD	Cement kiln dust

CL-SL	Cropland converted to settlements
cm	Centimeter
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2 eq.	Carbon dioxide equivalent
COD	Chemical oxygen demand
CORINAIR	Core Inventory of Air Emissions in Europe
CORINE	Coordinate Information on the Environment
CRF	Common Reporting Format
CRT	Common Reporting Table
CS	Country specific
CSC	Carbon stock change
D	Default
DG	Directorate of General
dm	Dry matter content
DOC	Degradable organic carbon
DoCC	Directorate of Climate Change
DOM	Dead Organic Matter
DOCF	Fraction of degradable organic carbon
EAF	Electric arc furnace
EF	Emission factor
EF_c	Baseline emission factor for continuously flooded fields without organic amendments
EHCIP	Environmental Heavy Cost Investment Planning
EMEP	European Monitoring and Evaluation Programme
ENVANIS	Inventory Statistical System for Forests
ERT	Expert Review Team
ETF	Enhanced Transparency Framework
EU	European Union
F	Fraction of methane
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Statistical database of the FAO
FCF	Fossil carbon content
F-gas	Fluorinated gas

FOD	First Order Decay
$Frac_{GASF}$	Fraction of synthetic fertiliser N that volatilises as NH_3 and NO_x
$Frac_{GASMS}$	Percent of managed manure nitrogen that volatilises as NH_3 and NO_x in the manure management system S
$Frac_{GASM}$	Fraction of applied organic N fertiliser materials and of urine and dung N deposited by grazing animals that volatilises as NH_3 and NO_x
$Frac_{LEACH-(H)}$	Fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff
$Frac_{LEACHMS}$	Percent of managed manure nitrogen losses due to runoff and leaching during solid and liquid storage of manure
F_{comp}	Annual amount of total compost N applied to soils
F_{sew}	Annual amount of total sewage N that is applied to soils
g	gram
GDF	General Directorate of Forestry
GDP	Gross Domestic Product
GE	Gross energy intake
Gg	Gigagram
GHG	Greenhouse gas
GIS	Geographical Information System
GJ	Gigajoule
GL-SL	Grasslands converted to settlement
GW	Gigawatt
GWh	Gigawatt hour
ha	Hectare
HAC	High activity clay
HFC	Hydrofluorocarbon
HWP	Harvested wood product
ICP	International Cooperative Programme
IE	Included elsewhere
IEA	International Energy Agency
IEF	Implied emission factor
IFA	International Fertilizer Association
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial processes and product use
IW	Industrial Waste

k	Methane generation rate constant
kha	Kilo hectare
KISAD	Lime Producers Association
km	kilometer
kt	Kilo tonnes
ktoe	Kilo tonnes of oil equivalent
kW	Kilowatt
kWh	Kilowatt hour
L	Litter
LPG	Liquefied petroleum gas
LRS	LULUCF reporting system
LTO	Landing and take-off
LULUCF	Land Use, Land Use Change and Forestry
MAPEG	General Directorate of Mining and Petroleum Affairs
MCF	Methane correction factor
ME	Main engine
MENR	Ministry of Energy and Natural Resources
$MgCO_3$	Magnesium carbonate
MgO	Magnesium oxide
MJ	Megajoule
MMS	Manure Management System(s)
MoAF	Ministry of Agriculture and Forestry
MoEF	Ministry of Environment and Forestry
MoEU	Ministry of Environment and Urbanization
MoEUCC	Ministry of Environment, Urbanization and Climate Change
MoT	Ministry of Trade
MoTI	Ministry of Transport and Infrastructure
MRV	Monitoring, Reporting, Verification
MS	Manure Management System Usage
MSm^3	Million standard cubic meter
MSW	Municipal solid waste
Mt	Million tonnes
MW	Megawatt

N	Nitrogen
N_2O	Nitrous oxide
NA	Not applicable
Na_2CO_3	Sodium carbonate
NaCl	Sodium cloride
NCV	Net calorific value
NE	Not estimated
NES	EU Integrated Environmental Adaptation Strategy
Nex	Annual nitrogen excretion
NF_3	Nitrogen trifluoride
NH_3	Ammonia
NID	National Inventory Document
NIR	National Inventory Report
NMVOC	Non-methane volatile organic compounds
NO	Not occurring
NO_x	Nitrogen oxides
ODS	Ozone-depleting substances
ODU	Oxidised During Use
OHF	Open hearth furnace
OSP	Official Statistics Programme
OX	Oxidation factor
PFC	Perfluorocarbon
PRODCOM	Industrial Production Statistics Survey
PS	Plant specific
QA/QC	Quality assurance and quality control
R	Root-to-shoot ratio
S	Soil
SEM	Ship Emission Model
SF_6	Sulphur hexafluoride
SFOC	Specific Fuel Oil Consumption
SF_o	Scaling factor regarding organic amendment type and amount applied
SF_p	Scaling factor regarding water regime before the cultivation period
$SF_{s,r}$	Scaling factor for soil type, rice cultivar, etc., if available

SF_w	Scaling factor regarding water regime during the cultivation period
SO_2	Sulphur dioxide
SO_x	Sulphur oxide
SOM	Soil Organic Matter
SWDS	Solid waste disposal sites
t	Tonnes
T	Degrees of treatment utilization
T_{PLANT}	Degree of utilization of modern, centralized wastewater treatment plan
T1	Tier 1
T2	Tier 2
T3	Tier 3
TACCC	Transparency, accuracy, comparability, consistency, and completeness
TADPK	Tobacco and Alcohol Market Regulatory Authority
TAGEM	General Directorate of Agricultural Research and Policies
TurkCimento	Turkish Cement Manufacturer's Association
TEİAŞ	Turkish Electricity Transmission Company
TJ	Terajoule
TOBB	The Union of Chambers and Commodity Exchanges of Türkiye
TOR	Terms of Reference
TOW	Total organics in wastewater
TPES	Total Primary Energy Supply
TRGM	General Directorate of Agricultural Reform
TTGV	Technology Development Foundation of Türkiye
TUBITAK	Scientific and Technical Research Council of Türkiye
TurkStat	Turkish Statistical Institute
TÜPRAŞ	Turkish Petroleum Refineries Co.
TWh	Terawatt hour
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
Vol	Volume
WF	Waste fractions
WG	Working group

Y_m	Methane conversion factor
yr	year

1. INTRODUCTION

1.1. Background Information on GHG Inventories

The UNFCCC, the Kyoto Protocol and the Paris Agreement were ratified by Türkiye in 2004, 2009 and 2021, respectively. As an Annex I party to Convention, Türkiye is required to develop annual inventories on emissions and removals of GHG not controlled by the Montreal Protocol using the IPCC Guidelines. National Greenhouse Gas Inventory of Türkiye was set up in 2006. Inventory covers all sources of emissions and removals described in 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines). Emissions and removals have been estimated and reported in line with the 2006 IPCC Guidelines. Since 2024 reporting has been done under the Paris Agreement and The National GHG Inventory consists of the national inventory document (NID) and the common reporting tables (CRT) in accordance with the UNFCCC reporting guidelines (18/CMA.1, Annex and 5/CMA.3). Time series of emissions and removals from 1990 to latest inventory year are covered in the Common Reporting Tables (CRT).

2006 IPCC Guidelines were provided for the following sectors:

- Energy
- Industrial Processes and Product Use (IPPU)
- Agriculture
- Land Use, Land Use Change and Forestry (LULUCF)
- Waste

The emission inventory includes direct GHGs as CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3 and indirect gases as NO_x, CO, NMVOC, SO_2 and NH_3 emissions originated from energy, IPPU, agriculture, and waste. The emissions and removals from LULUCF are also included in the inventory. Indirect CO_2 emissions that are among the consequences of the activities of the reporting entity, but available at sources owned or controlled by another entity do not occur.

In this report, the national GHG emissions and removals from 1990 to 2022, emission and removal sources, emission factors (EFs), difference between reference and sectoral approach, emission trends, fluctuations, changes, uncertainty estimations and key categories were evaluated in detail.

1.2. Institutional Arrangements

1.2.1. Institutional, Legal and Procedural Arrangements

The Turkish national inventory system is featured by centralized governance. Ministry of Environment, Urbanization and Climate Change (MoEUCC) is the National Focal Point of the UNFCCC, and is responsible for climate change and air pollution policies and measures. Türkiye established the Coordination Board on Climate Change (CBCC) in 2001 with the Prime Ministerial Circular No. 2001/2 in order to determine the policies, measures and activities to be pursued by Türkiye on climate change. Under the chairmanship of MoEUCC, this board is composed of high level representatives (Undersecretary and President) from Ministries related to foreign relations, finance, economy, energy, transport, industry, agriculture, forestry, health, education, TurkStat, and Non-Governmental Organisations (NGOs) from business sector. The CBCC was restructured in 2013, and renamed as Coordination Board on Climate Change and Air Management (CBCCAM). The CBCCAM, a public body created by Prime Minister Circular 2013/11, is competent for taking decisions and measures related to climate change and air management. The CBCCAM decisions are the first legal means for the national inventory system.

Türkiye has also taken steps to strengthen its institutional arrangements. In 2021, Türkiye established a new Directorate of Climate Change (DoCC) under the MoEUCC with Presidential Decree No. 85 on Amending Certain Presidential Decrees. With the same decree, CBCCAM was replaced by the Coordination Board on Climate Change and Adaptation (CBCCA), and it was stated that climate change negotiations would be conducted by a Chief Negotiator (Relevant Deputy Minister). In addition, it was stated that the Secretariat services of the Coordination Board would be carried out by the DOCC. The Coordination Board is responsible for determining, monitoring, and evaluating plans, policies, strategies, and actions related to climate change. The Coordination Board, which is an an inter-ministerial coordination mechanism and chaired by the Minister, consists of twenty-two members, including TurkStat.

The draft directive on the working procedures and principles of the Coordination Board will be prepared by the DoCC, and within this scope, sub-working groups will be formed, the details of which will be determined in the directive. Since studies on this directive are still ongoing, current studies are carried out with seven working groups (WGs) within the scope of the CBCCAM:

- GHG Mitigation WG
- Climate Change Adverse Effects and Adaptation WG
- GHG Emission Inventory WG
- Finance WG

- Technology Development and Transfer WG
- Education, Capacity Building WG
- Air Management WG

The national GHG inventory is prepared under the auspices of the "GHG Emission Inventory Working Group" which was established in 2001 by the former CBCC. TurkStat was formally appointed as single national responsible authority to coordinate and implement national inventory activities from planning to management by Decision 2009/1 of the CBCC in 2009. TurkStat is also in charge of annual inventory submission to the UNFCCC Secretariat and of responding to the ERT recommendations.

Also, the legal basis of the national inventory system is currently provided by the Statistics Law of Türkiye through the Official Statistics Programme (OSP). The OSP is based on the Statistics Law of Türkiye No. 5429 and Presidential Order No. 4, and was first prepared in 2007 for a 5-year-period and updated every 5 years. OSP identifies the basic principles and standards dealing with the production and dissemination of official statistics and produces reliable, timely, transparent and impartial data required at national and international level. For all kinds of official statistics, the responsible and related institutions are defined, data compilation methodology and the publication periodicity/schedule of official statistics are specified. TurkStat is the responsible institution for the compilation of the national GHG inventory through the OSP and coordinates the activities of the GHG emission inventory working group established in the scope of OSP with the same composition as the GHG emission inventory working group under the CBCCAM.

The GHG national inventory is compiled by GHG Emission Inventory working group under the coordination of TurkStat.

The institutions included in the working group are:

- Turkish Statistical Institute (TurkStat),
- Ministry of Energy and Natural Resources (MENR),
- Ministry of Transport and Infrastructure (MoTI),
- Ministry of Environment, Urbanization and Climate Change (MoEUCC),
- Ministry of Agriculture and Forestry (MoAF).

The national inventory arrangements are designed and operated to ensure the TACCC quality objectives and timeliness of the national GHG inventories. The quality requirements are fulfilled by implementing consistently inventory quality management procedures.

Responsibilities of the institutions involved in the national GHG inventory are shown in Table 1.1.

Table 1.1 Institutions by responsiblities for national GHG inventory

Sector	CRT category	Collection of AD	Selection of methods and EFs	GHG emission calculations	Filling in CRT tables and preparing NID	Quality control
Energy	1 –Energy (Excluding 1.A.1.a – Public electricity and heat production, and 1.A.3 – Transport)	MENR, TurkStat	TurkStat	TurkStat	TurkStat	TurkStat
	1.A.1.a – Public electricity and heat production	MENR	MENR	MENR	MENR	MENR
	1.A.3 – Transport	MoTI, TurkStat	MoTI	MoTI	MoTI	MoTI
Industrial processes and product use	2 – IPPU (except F-gases)	TurkStat	TurkStat	TurkStat	TurkStat	TurkStat
	F-gases	MoEUCC	MoEUCC	MoEUCC	MoEUCC	MoEUCC
Agriculture	3 – Agriculture	TurkStat	TurkStat	TurkStat	TurkStat	TurkStat
Land use, land-use change and forestry	4 – LULUCF	MoAF	MoAF	MoAF	MoAF	MoAF
Waste	5 – Waste	TurkStat	TurkStat	TurkStat	TurkStat	TurkStat
Cross cutting issues						
Key category analysis Uncertainty analysis			TurkStat			

National Inventory Official Consideration and Approval

The national GHG inventory is subject to an official consideration and approval procedure before its submission to the UNFCCC. The national inventory is subject to a two-step official consideration and approval process. The final version of the NID and CRT is first approved by the TurkStat Presidency and published in the official TurkStat press release. The latest press release of Greenhouse Gas Emissions Statistics can be found on https://data.tuik.gov.tr/Bulten/Index?p=Greenhouse-Gas-Emissions-Statistics-1990-2022-53701 as scheduled on National Data Publishing Calendar. Subsequently, The MoEUCC as National Focal Point to the UNFCCC provides final checks and approval of the CRT via ETF web application tool as a final step prior to its submission to the UNFCCC.

TurkStat, as the Single National Entity, is responsible for official inventory submission to UNFCCC, and also responsible for responding to the UNFCCC expert review team (ERT) recommendations on national inventory improvement and ensuring they are incorporated in the current and following NID(s) in the broader context of its continuous improvement.

1.2.2. Overview of Inventory Planning, Preparation and Management

The inventory planning system of Türkiye is conducted in line with quality assurance and quality control (QA/QC) plan. Planning stage is under the responsibility of GHG Inventory WG. Planning activities include data collection and processing, selection of EF estimation methodology, compilation of CRT and NID, UNFCCC expert review team (ERT) recommendations, documentation and archiving, verification through time series consistency and cross checks, reporting and publication process.

Every year in the autumn, about October, WG meeting is organized to agree on a work plan and calendar for the following submission.

Information required for the inventory are mostly covered by OSP. Distribution of work for data gathering, processing and estimation of emissions are shown in Table 1.1. Emissions originating from energy, industrial processes and product use, agriculture and waste, and emissions and removals from LULUCF are calculated at national level annually by using recommended approaches in 2006 IPCC Guidelines. Fuel combustion emissions other than electricity generation and transport are calculated by TurkStat via using the energy balance tables of the Ministry of Energy and Natural Resources. Emissions from industrial processes (excluding F-gases), agriculture, waste and fugitive emissions from coal mining, oil and gas systems are also calculated by TurkStat. The emissions originating from public electricity and heat production are calculated on the basis of plant level data by the Ministry of Energy and Natural Resources; the emissions originating from transportation are calculated by the Ministry of Transport and Infrastructure. The fluorinated gases are calculated by the Ministry of Environment, Urbanization and Climate Change. Emissions and removals from land use, land-use change and forestry are estimated by the Ministry of Agriculture and Forestry.

Every sector expert that performs the emission estimation is responsible for the data entry to ETF Reporting Tool, and preparation of the related section or sub-section of NID. TurkStat compiles and makes key category and uncertainty analysis and does final quality checks, and submits the national GHG inventory to the UNFCCC Secretariat.

TurkStat is also responsible for archiving the GHG inventory. Central archiving is carried out by TurkStat. EFs, AD, calculation sheets, CRT and NID outputs, etc. regarding the emission inventory are archived on TurkStat main server. All inventory related documents are also archived by the relevant Ministries for the CRT categories under their responsibilities.

1.2.3. Quality Assurance, Quality Control and Verification

QA/QC and verification procedures are an integral and indispensable part of the national GHG inventory of Türkiye. The quality of the national inventory system is ensured by the QA/QC system, through the QA/QC plan adopted by the CBCCAM decision in 2014 and revised and updated in 2017. The QA/QC plan introduces the structure and purpose of the QA/QC system, endorse the quality objectives. The main objective of the QA/QC plan is to ensure that the national GHG inventory is prepared in accordance with the quality objectives: transparency, accuracy, comparability, consistency, completeness (TACCC) as defined in UNFCCC reporting guidelines (18/CMA.1, Annex and 5/CMA.3). Türkiye also considers three additional quality objectives as improvement, sustainability and timeliness.

Improvement: Processes ensure that the inventory represents the best possible estimates of GHG emissions and removals for all categories, given the current state of scientific knowledge, data availability and national resources, taking into account information gained and lessons learned from reporting and review in the latest GHG inventory cycle.

Sustainability: Processes ensure the continuity of the GHG inventory system through institutional memory by establishing a documentation/archiving system and methodological manuals, as well as a training for newcomers and periodic refreshment trainings for existing inventory experts.

Timeliness: All of the QA/QC procedures are developed with a view to enabling the timely submission of the NID and the accompanying CRT to the UNFCCC by 15 April each year. In addition, inventory inputs, references and materials should be transparently documented and accessible, to enable timely responses to external requests for information, including formal and informal inventory review processes.

Together with verification, the implementation of QA/QC procedures are considered integral part of national inventory preparation and play a pivotal role not only to achieve the quality objectives but also for continuous reassessing and improving the national inventory where needed.

TurkStat is the designated body for overall implementation of the QA/QC system and for ensuring coordination of the QA/QC activities.

Quality Control (QC) is a system of routine technical activities to assess and maintain the quality of the inventory as it is being compiled. It is performed by personnel compiling the inventory. QC activities include general methods such as accuracy checks on data acquisition and calculations, and the use of approved standardised procedures for emission and removal calculations, measurements, estimating uncertainties, archiving information and reporting. QC activities also include technical reviews of categories, activity data, emission factors, other estimation parameters, and methods.

The data used in the preparation of the national GHG inventory for the IPPU, agriculture, and waste sectors are obtained from industrial production statistics, agricultural statistics, and waste statistics databases of TurkStat. TurkStat is producing all its statistics according to the European Statistics Code of Practice which covers a common quality framework with the European Statistical System. Therefore, high quality data are used in the inventory.

In Türkiye, in addition to data available from national statistics, some plant-level data are used to estimate input parameters for emissions calculations. No QC procedures are available for data providers at the moment. If data are official statistics from TurkStat, then it is ensured that the statistics are produced in line with the EU code of practice. However, if the data source is not from the official statistics QC can be performed by the inventory team.

In detail, with regard to QC the following rules and steps apply:

- Each institution involved in national inventory development is responsible for its own general and category specific QC activities,
- Both general and category specific QC activities are carried out by sectorial QC experts within the Institutions, using the ad hoc check lists attached in Annex II (general QC) and Annex III (category specific) of the QA/QC plan,
- Check lists are filled in by sectorial QC experts for the CRT categories under their responsibility and sent to TurkStat with an official letter,
- TurkStat files the letters,
- QC sectorial experts make the corrections needs emerging from the QC activities,
- TurkStat prepares a summary of the QC results,
- An improvement plan is prepared by the national inventory team under TurkStat coordination.

The QA/QC plan (approved in 2017) including above mentioned annexes can be found at *https://biruni.tuik.gov.tr/yayin/views/visitorPages/english/index.zul*.

Criteria for assessing achievement of quality objectives is given below in Table 1.2.

Table 1.2 Criteria for assessing achievement of quality objectives

Data quality objective	Criteria for assessing achievement of quality objective
Accuracy	• Emissions are neither overestimated or underestimated as far as can be judged, • Uncertainty estimates are provided for AD, EF, and emissions in each category for the base year, the most recent year, and the trend.
Comparability	• Türkiye applies methods from the 2006 IPCC Guidelines, in accordance with the significance of the category in the country (e.g., whether or not it is a key category) and national circumstances.
Completeness	• All categories for which methods are provided in the 2006 IPCC Guidelines are included in the national GHG inventory, • Emissions estimates cover the entire geographic area of Türkiye, • Emissions values or notation keys are provided for each cell in the CRT, • If despite the best efforts, emissions for a category for which methods are provided in the 2006 IPCC Guidelines cannot be provided, the situation regarding the lack of reporting is transparently described in the NID.
Consistency	• Türkiye has applied the same method across the time series for a given category and can explain the trends observed in the time series, • If the same method is not used for the entire time series in a category, Türkiye can explain (and documents in the NID) why the selected method(s) ensure time series consistency.
Improvement	• The national inventory improvement plan is updated with the recommendations and encouragements from the relevant review processes (e.g. UNFCCC) and QA/QC summary reports, • Türkiye implements findings from review processes where feasible.
Sustainability	• All inventory related documents (NID, data sheets, EFs, CRT tables) are archived annually, • All information on choice of methodology, EFs and parameters, assumptions used, are documented and updated as needed, • All methodological manuals are prepared and updated as needed.

Table 1.2 Criteria for assessing achievement of quality objectives (cont'd)

Data quality objective	Criteria for assessing achievement of quality objective
Timeliness	• Inventory is submitted to the UNFCCC by 15 April annually (except for first BTR), • Türkiye is able to timely respond to questions from the UNFCCC ERT.

Transparency	• Information necessary to reproduce the emissions estimates is either provided in the annual submission or referenced therein,
	• The elements required to be included in the NID per paragraph 50 of the annex to decision 18/CMA.1, Annex are included, in particular clear descriptions of:
	  ○ All methods selected and models used
	  ○ Values and sources of AD, EFs and other parameters
	  ○ Relevant information on key categories and uncertainties
	  ○ Recalculations are clearly explained
	  ○ Completeness of the inventory
	  ○ Changes in response to the review process
	  ○ Description of the national inventory arrangements.

General QC Procedures

General QC procedures include generic quality checks related to calculations; data processing, completeness, and documentation that are applicable to all inventory source and sink categories. General QC procedures are applied routinely to all categories by sector experts using the check lists attached in Annex II of the QA/QC plan during the acquisition of data and the emissions calculation procedures and during the compilation of NID and the CRT.

Each sector expert should fill and sign the check list that the necessary QC checks were undertaken. Each sector expert should carry out immediate corrections of the input data/emissions calculations where errors are found. If an issue cannot be resolved during the current inventory submission, the sector experts should include an explanation for aspects still posing problems along with a recommendation(s) for future work on these issues. Such issues may then be incorporated into the inventory improvement plan. A copy of the completed checklist is sent to TurkStat and is archived in TurkStat.

The types of activities and procedures undertaken by sectoral experts include, but are not limited to:

- Cross-check descriptions of AD, EFs and other estimation parameters with information on categories and ensure that these are properly recorded and archived. This step includes ensuring that definitions and assumptions for the underlying AD match the definitions of categories used in the GHG inventory. In some cases, data collected from national statistics may have different coverage than that required for inventory preparation,
- Ensure that the time series of input EF, AD and other parameters are justifiable, and that any outliers can be explained by national circumstances,
- Ensure that proper bibliographic information is available and documented in the archives for all input parameters,
- Cross-check a sample of input data to ensure that there are no transcription errors,
- Where AD or EF data are obtained from plant operators, Türkiye plant level data are compared with previous data and related indicators (kwh/TJ, kwh/m^3 CH_4) and published national data,
- Check that units are properly labeled for all input data and, for a subset of parameters, correctly transcribed and applied in the emissions calculation spreadsheets,
- Where a parameter is based on expert judgement, identifying information for the expert (including their affiliation and any relevant expertise) is documented and archived,
- Has the sector expert identified where recalculations of previous input data have been undertaken? Qualitative reasons for, and the quantitative impacts of, these recalculations should be documented in the NID.

Category-Specific QC Procedures

Category-specific QC procedures complement general inventory QC procedures and are directed at specific types of data used in calculating GHG emissions for individual source or sink categories. These procedures require knowledge of the specific category, the types of data available and the parameters associated with emissions or removals, and are performed in addition to the general QC checks. Category specific QC procedures are also applied by sector experts using the check lists attached in Annex III of the QA/QC plan.

Each sector expert should fill and sign the check list that the necessary QC checks were undertaken, and summarizes the unsolved issues. A copy of the completed checklist is sent to TurkStat and is archived in TurkStat.

The types of activities and procedures undertaken by sectoral experts include, but are not limited to:

- Assumptions for AD, EFs and other parameters are compared with IPCC values and significant differences are noted,
- National and regional comparability and trends of AD, EF or other assumptions are checked against alternative data sources,
- Conduct of an in-depth review of the background data used to develop a country-specific EF, including the adequacy of any plant-level measurement programmes upon which the country-specific EF was developed. Such an in-depth review may also involve an assessment of any national literature used in support of the development of the country-specific factor,
- Evaluate any peer reviewed literature evaluating national or plant level statistics and suitability for the use in the GHG inventory,
- Hand-checking the accuracy of random calculations,
- To the extent possible, are the only hardwired data in the spreadsheets the basic input data (e.g., AD, EFs and assumptions) with all other spreadsheets using spreadsheet tools to link and calculate emissions,
- Reviewing the time series consistency of emissions calculations for any outliers and compare whether the values are within the minimum – maximum interval of other Parties,
- Checking a random sampling of conversion factors to ensure proper calculation from input data to emissions calculations,
- Is the IEF calculated reasonable compared with the previous annual submission and with the 2006 IPCC Guidelines,
- Is the time series of the IEF reasonable- are any large changes explainable,
- Checking that confidentiality is assured by Statistics Law of Türkiye,
- Are emissions estimates (or notation keys) available for all years of the time series for mandatory categories, from 1990 to the year "t-2" and do the emissions estimates cover all sources in the category (as determined by cross checks using other publicly available information),
- Identify parameters (e.g., AD, constants) that are common to multiple categories and confirm that there is consistency in the values used for these parameters in the emission/removal calculations. This is particularly important when reviewing calculations for the agriculture and LULUCF sector, as well as when reviewing input data between the reference and the sectoral approach.

QC Procedures Applied to Compiled NID and CRT

TurkStat undertakes further quality checks on compiled CRT and NID. The types of activities and procedures undertaken include:

CRT

- Completeness of all cells in the CRT with either a value or a notation key,
- Appropriateness of notation keys used ,
- Where the notation key "NE" or "IE" is used, whether an appropriate description is included in CRT table 9 to indicate why data are not reported (in the case of "NE") or where data are reported (in case of "IE"),
- Where emissions data are reported as confidential, it is ensured that emissions are included elsewhere (properly aggregated to assure confidentiality of information) and, therefore, included in national totals,
- Check whether appropriate tiers are used for key categories, in accordance with the decision trees in the 2006 IPCC Guidelines. Where appropriate tiers are not used, is an appropriate discussion included in the NID to document the national circumstances surrounding the methodological choice?
- Review of documentation boxes of the CRT for appropriate content and language.

NID

- All tables, figures and text have been updated to reflect the latest annual data,
- Does the description of trends match the trends seen taking into account the latest year, and any recalculations of earlier years' data,
- Check the introductory chapters and annex to make sure that the data contained therein match the latest inventory data,
- Have all recalculations identified been documented in the NID and the impacts of the recalculation described?
- Assessment of completeness of the category described in the NID,
- Consistent use of units in the NID and the CRT,
- A general check of the NID should be done for consistency,
- All references should be included in the NID and the same reference should be referred to consistently across chapters,
- Ensure that all web links are active and direct the readers to the appropriate content.
- After inventory submission to UNFCCC, ensures that all inventory related materials were archived by inventory sectoral experts.

In 2019 submission, emissions from energy, IPPU and agriculture sectors were calculated on SAS (Statistical Analysis System) and it was double checked by the calculations on the Excel sheets by two different experts and any finding errors were corrected.

Quality Assurance

Quality Assurance (QA) is a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Reviews, preferably by independent third parties, are performed upon a completed inventory following the implementation of QC procedures. Reviews verify that measurable objectives (data quality objectives) were met, ensure that the inventory represents the best possible estimates of emissions and removals given the current state of scientific knowledge and data availability, and support the effectiveness of the QC programme.

Due to the comprehensive and costly nature of QA activities, these procedures are only applied for selected categories and selected years, and generally only for key categories.

Our approach to QA is to prioritize:

- The categories that have high uncertainty,
- The categories that are recalculated,
- The categories that were included in the improvement plan.

In Türkiye, QA activities are conducted by experts in the scope of European Union (EU) funded Projects. For this purpose, first, in the scope of EU funded Upgrading the Statistical System of Türkiye project, external experts from EU countries were invited to review Turkish GHG Inventory for all categories before in-country review in 2014. Some improvements has been achieved based on review outputs of the EU inventory experts.

Also the EU funded Project named as Technical Assistance for Support to Mechanisms for Monitoring Türkiye’s GHG Emissions, project period was January 2015 - April 2017, aimed to strengthen existing capacities in Türkiye and assist the country to:

- Fully implement a monitoring mechanism of GHG emissions in Türkiye, in line with the EU Monitoring Mechanism Regulation 525/2013 repealing Decision 280/2004/EC, and
- Better fulfill its reporting requirements to the UNFCCC, including national GHG inventories, National Communications and Biennial Reports.

Under the technical assistances of experts from project team national GHG inventory was reviewed and improved through workshops, mentor style trainings, and meetings organized.

For the period 2017-2019, TurkStat was responsible for implementing an investment project with the objective of improving the GHG Inventory. Under this project, a QA work was conducted for the agriculture sector in 2017. Likewise, another QA work was conducted for the energy sector in 2018.

"Technical Assistance for New Era for Statistics Programme" which is co-funded by the European Union and the Republic of Türkiye, has been started since March 2019. Within the scope of this project, under sub-activity "National Greenhouse Gas Inventory", the experts from CITEPA – Technical Reference Center for Air Pollution and Climate Change – provided QA works for the energy, IPPU, agriculture and waste sectors of the Turkish GHG Inventory between December 2019 and February 2020.

In addition, GHG inventory submission of Türkiye is subject to review by an international team of experts on an annual basis in accordance with decision 18/CMA.1, Annex. During the review week, Türkiye ensures that all institutions, organizations and responsible sector experts are available to provide necessary information and supporting documentation to the review team in a timely manner. The Expert Review Team (ERT) then develops an annual review report based on the findings of the review. These annual review reports are considered as supplementary to the QA procedures undertaken by experts in Türkiye. Findings in the annual review reports are considered feedback for improvement of the GHG inventory, and as such are included in inventory improvement plan of Türkiye.

Verification

Verification activities typically include comparing inventory estimates with independent estimates to either confirm the reasonableness of the inventory estimates or identify major discrepancies. Verification activities may be directed at specific categories or the inventory as a whole, and their application will depend on the availability of independent estimation methodologies that can be used for comparison.

Each institution involved in national inventory development is responsible for its own verification activities. Sectorial experts within the Institution carry out the activities.

In Türkiye, some level of verification happens on an annual basis, as Türkiye estimates and reports CO_2 emissions from fossil fuel combustion based on both the reference approach and the sectoral approach. Differences in the emissions estimated using these two approaches are described in the NID.

The national GHG emissions in the energy sector are estimated by using fuel consumption data taken from energy balance tables produced by the MENR. These data are compared with International Energy Agency (IEA) data. Inconsistencies between two data sets are identified and the reasons for these inconsistencies are investigated.

Also lower tier IPCC methods are applied for comparison in especially energy sector. Emissions calculated and reported on the basis of higher tiers (Tier 2 or Tier 3) are compared with emissions calculated by Tier 1 method.

The Regulation on the Monitoring of Greenhouse Gases, which came into force in 2012, requires companies to report verified greenhouse gas (GHG) emissions data to the Ministry of Environment, Urbanization, and Climate Change (MoEUCC) beginning in 2015. Under this regulation, more than 800 facilities in the energy and industrial sectors are mandated to submit verified annual emissions data. This data is collected in compliance with MoEUCC regulations and serves as a foundation for accurate emissions accounting across key sectors.

In the coming years, emissions calculations for specific sub-sectors will rely on MRV data provided by the MoEUCC. This MRV data will undergo thorough analysis for essential quality attributes, such as coverage, accuracy, completeness, and consistency, to ensure the reliability of reported information.

To ensure comprehensive and standardized MRV data, consultations with MoEUCC are ongoing to gather activity data and refine classifications. Once the data is standardized and complete, an accounting system will be established to calculate emissions using both current methodologies and MRV data. The results will be tracked and compared over two years. Only after this comparison will the data be integrated into the National Greenhouse Gas Inventory.

Documentation and Archiving

Regarding documentation and archiving, all sectoral experts archive all inputs used in the inventory process, outputs, selected EFs, work files, e-mails and official letters on their computer, on a network server with restricted access or on an external drive as softcopy or as hardcopy. Archiving is done according to Regulation on State Archive Services. Sectoral experts are responsible for archiving in their own institutions.

Central archiving is carried out by TurkStat. EFs, AD, calculation tables, CRT and NID outputs, etc. regarding the emission inventory are stored on TurkStat main server. Sectoral experts transfer EFs, AD and calculation tables used in emission calculations to TurkStat within 6 weeks following the date of submission of the Annual Inventory to UNFCCC Secretariat.

1.3. Brief Description of the Process of Inventory Preparation

Inventory preparation of Türkiye starts with inventory planning which covers recalculations, methodological improvements and refinements according to quality management and improvement plans based on learning from previous inventory cycle, UNFCCC review reports and collaborations with government institutions. Firstly, reviewing the calculation methods are finalized and the data collection process is completed. After that, emission estimates and QC checks are done and data are uploaded to the CRT Reporter. NID text and tables are then prepared according to UNFCCC guidelines. The inventory process also involves key category assessment, recalculations, uncertainty assessment, documentation and archiving. Main steps in the annual inventory preparation process are summarized below in Table 1.3.

Table 1.3 Activities for preparation of the annual inventory submission

	Activities
1.	Inventory planning by GHG Inventory WG (Creating Inventory Improvement Plan, recalculation, etc.)
2	Reviewing emission calculation methods, EFs, AD sources, etc. by GHG Inventory WG
3.	Collection of AD and QC of the data by the institutions involved
4.	Calculation of all emissions from electricity production, transportation, F-gas, emissions and removals from LULUCF by the related institutions, and transfer to TurkStat
5.	Calculation of emissions under the responsibility of TurkStat
6.	QC of the calculated emissions
7.	AD and emission entry into the CRT Reporter by sectoral experts
8.	Performing key category, trend and uncertainty analysis by TurkStat
9.	Preparation of National Inventory Report by the institutions involved and compilation by TurkStat
10.	Release of the GHG Emissions Statistics as press release on TurkStat webpage
11.	Sending National GHG Inventory for approval by Inventory Focal Point (National Inventory Compiler)
12.	Approval of National GHG Inventory by National Focal Point
13.	Reporting of Inventory to UNFCCC Secretariat by TurkStat
14.	Documentation and archiving processes

1.4. Brief General Description of Methodologies and Data Sources

The National GHGs are calculated by using 2006 IPCC Guidelines. CO_2 emissions from energy are calculated by using Tier 2 (T2) approach except for biomass and other fossil fuels. CH_4 and N_2O emissions from all subcategories of energy excepting 1A1a category are calculated by using Tier 1 (T1). Technology specific EFs are used for CH_4 and N_2O emissions from 1A1a category. For the emissions from coke production, due to plant specific data are gathered, Tier 3 (T3) methodology are used.

For industrial process and product use, T2 methodology was used for the CO_2 emissions from cement production, ammonia (NH_3) production. T3 methodology is used for CO_2 emissions from iron and steel production and GHG emissions from aluminum production. For the emissions from rest of the IPPU categories, T1 methodology was used.

For agriculture sector; T2 is used for emissions from cattle enteric fermentation. For the other categories T1 methodology was used.

For LULUCF; T2 methodology was used for the emissions/removals from forestland, cropland, grassland and emissions from harvested wood product (HWP). For the other categories T1 methodology was used.

In waste sector; for the CO_2 emissions from open burning of waste, which is only CO_2 emission source for waste sector is calculated by using T2 method. For CH_4 emissions from solid waste disposal and wastewater treatment and discharge, T2 methodology was used while T1 was used for the other non-key categories. For N_2O emissions, T1 methodology was used for all relevant categories.

All tier methodologies are summarized on sector basis in below Table 1.4.

Table 1.4 Summary for methods and emission factors used, 2022

Greenhouse Gas Source and Sink Categories	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	T1,T2,T3	CS,D,PS	T1,T2,T3	D,PS	T1,T2,T3	D,PS
A. Fuel combustion	T1,T2,T3	CS,D,PS	T1,T2,T3	D,PS	T1,T2,T3	D,PS
1. Energy industries	T2,T3	CS,D,PS	T2,T3	D,PS	T2,T3	D,PS
2. Manufacturing industries and construction	T1,T2	CS,D	T1	D	T1	D
3. Transport	T1,T2	CS,D	T1,T2	D	T1,T2	D
4. Other sectors	T1,T2	CS,D	T1	D	T1	D
B. Fugitive emissions from fuels	T1	D	T1	D	T1	D
1. Solid fuels	NE	NE	T1	D	NE	NE
2. Oil and natural gas	T1	D	T1	D	T1	D
C. CO_2 transport and storage	T1	D				
2. Industrial processes and product use	T1,T2,T3	CS,D,PS	T1	D	T1	D
A. Mineral industry	T1,T2	CS,D				
B. Chemical industry	T1,T2	CS,D	NE	NE	T1	D
C. Metal industry	T1,T2,T3	CS,D,PS	T1	D	NO	NO
D. Non-energy products from fuels and solvent use	T1	D	NA	NA	NA	NA
E. Electronic industry						
F. Product uses as ODS substitutes						
G. Other product manufacture and use	NA	NA	NA	NA	NE	NE
H. Other	NA	NA	NA	NA	NA	NA
3. Agriculture	T1	D	T1,T2	CS,D	T1	D
A. Enteric fermentation			T1,T2	CS,D		
B. Manure management			T1	D	T1	D
C. Rice cultivation			T1	D		
D. Agricultural soils					T1	D
E. Prescribed burning of savannas			NO	NO	NO	NO
F. Field burning of agricultural residues			T1	D	T1	D
G. Liming	NE	NE				
H. Urea application	T1	D				
I. Other carbon-containing fertilizers	NO	NO				
J. Other	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry	T1,T2,T3	CS,D	T1	D	T1	D
A. Forest land	T2,T3	CS,D	T1	D	T1	D
B. Cropland	T1,T2	CS,D	NE	NE	T1	D
C. Grassland	T1,T2	CS,D	NE	NE	T1	D
D. Wetlands	T1,T2	CS,D	NE	NE	T1	D
E. Settlements	T1	D	NE	NE	NE	NE
F. Other land	T1	D	NO	NO	NO	NO
G. Harvested wood products	T2,T3	CS,D				
H. Other	NO	NO	NO	NO	NO	NO
5. Waste	T2	CS,D	T1,T2	CS,D	T1	D
A. Solid waste disposal	NA	NA	T2	CS,D		
B. Biological treatment of solid waste			T1	D	T1	D
C. Incineration and open burning of waste	T2	CS,D	T1	D	T1	D
D. Waste water treatment and discharge			T2	CS	T1	D

Table 1.5 provides an overview for inventory data sources by sectors;

Table 1.5 Activity data sources for GHG inventory

Sector	Category	Activity data source
Energy	Energy – 1 (excluding 1.A.1 – Energy industry and 1.A.3 – Transportation)	MENR Energy balance sheet-sectoral fuel consumption data (for sectoral approach) and fuel supply data (for reference approach) Directorate of Energy Efficiency and Environment and PETKIM - waste incineration data
	Public electricity and heat production – 1.A.1.a	MENR - Facility base electricity and heat production statistics
	Petroleum Refining– 1.A.1.b	TÜPRAŞ- STAR Rafineri emission data
	Manufacture of solid fuels and other energy industries– 1.A.1.c	Integrated iron and steel plants- fuel consumption for coke production
	Transportation – 1.A.3	TurkStat-road vehicle fleet and vehicle-km travelled, MENR, MAPEG - fuel consumption by transport mode MoTI/DG of State Airports Authority - air traffic data
Industrial Process and Product Use	2.A.1.Cement	Turkish Cement Manufacturer's Association- production data, Producers- production data and EF, TurkStat- Industrial production statistics
	2.A.2. Lime	Turkish Lime Association- production data, Producers- production data and EF, Steel plants- production data, TurkStat- Industrial production statistics
	2.A.3 Glass	Producers- glass production data and parameters
	2.A.4 Other process uses of carbonates	Turkish Ceramics Federation- production data, Producers- production and raw material consumption data, TurkStat- Industrial production and foreign trade statistics
	2.B.1. Ammonia Prod.	Producers- production and fuel consumption data BOTAS (Petroleum Pipeline Corporation)- Carbon content of natural gas, TurkStat- Industrial production statistics
	2.B.2 Nitric Acid Prod.	Producers- production data and technology TurkStat- Industrial production statistics
	2.B.5. Carbide Prod.	TurkStat-Foreign trade statistics and industrial production statistics
	2.B.7. Soda ash prod.	Producers- production and raw material data
	2.B.8. Petrochemical and carbon black prod.	Producers- production data
	2.C.2. Iron and Steel Prod.	Producers- production data and other parameters Turkish Steel Producers Association- production data
	2.C.2. Ferroalloy prod.	Producers- production data TurkStat- Industrial production statistics
	2.C.3 Aluminium Prod.	Producer- production data and other parameters
	2.C.4 Magnesium Prod.	Producer- production data and other parameters
	2.C.5. Lead Prod.	TurkStat- MoEUCC recycled waste batteries data
	2.C.6. Zinc Prod.	Producers- production data, TurkStat- Industrial production statistics
	2.D.1. Lubricant Use	MENR- consumption data
	2.D.2. Paraffin wax use	MENR- consumption data

Table 1.5 Activity data sources for GHG inventory (cont'd.)

Sector	Category	Activity data source
	2.E. Electronic industry	TurkStat - trade statistics
	2.F. Product uses as substitutes for ODS	Ministry of Trade (MoT) - trade statistics
	2.G.1. Electrical equipment	MoT - trade statistics - Turkish Electricity Transmission Corporation (TEİAŞ)
Agriculture	Agriculture – 3	TurkStat - Livestock population Crop production data Waste disposal and treatment statistics General Directorate of Meteorology - Temperature data MoAF- Inorganic N Fertilizers application data, urea application data
Land Use, Land Use Change and Forestry	LULUCF – 4	MoAF (General Directorate of Forestry) - Landsat Satellite Images Copernicus HRL for Forest (Sentinel) Forestry Statistics The annual commercial cutting and fuel wood data The annual forest fire information The annual illegal cutting and wood gathering information MoAF (General Directorate of Agricultural Reform) - Landsat Satellite Images CORINE land use maps LPIS General Directorate of State Hydraulic Works - the data of dam constructions MoAF (General Directorate of Agricultural Research and Policies) - Soil Information System
Waste	Waste – 5	TurkStat - Waste disposal and treatment statistics Wastewater discharge and treatment statistics GDP Population estimations and projections MoEUCC, TurkStat - waste composition data Composting plants - amount of composted waste Methane recovery facilities - amount of methane recovered from landfills and wastewater treatment plants

1.5. Brief Description of Key Categories

The 2006 IPCC Guidelines for National GHG Inventories (2006 IPCC Guidelines) recommend as good practice the identification of key categories of emissions and removals. The intent is to help inventory agencies prioritize their efforts to improve overall estimates. A key category is defined as "one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of GHG in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions and removals" (2006 IPCC Guidelines); this term is used in reference to both source and sink categories.

For the 1990-2022 GHG inventory, level and trend key category assessments were performed according to the recommended IPCC approach found in Volume 1, Sections 4.3.1 and 4.3.2 of the 2006 IPCC Guidelines. The details of key category analysis are given in Annex 1.

Based on the Approach 1 key category analysis (with and without LULUCF) and on the Approach 2 key category analysis without LULUCF, the followings are determined as key categories in 2022.

Table 1.6 Key categories for GHG inventory, 2022

Key Categories of Emissions and Removals	Gas	Criteria used for key source identification		Key category exc. LULUCF	Key category inc. LULUCF
		L	T		
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO_2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	X	X	X	X
1.A.3.a Domestic Aviation	CO_2	X		X	X
1.A.3.b Road Transportation	CO_2	X	X	X	X
1.A.3.b Road Transportation	N_2O	X		X	
1.A.4 Other Sectors - Liquid Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Liquid Fuels	N_2O	X	X	X	
1.A.4 Other Sectors - Solid Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Solid Fuels	CH_4		X	X	
1.A.4 Other Sectors - Gaseous Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Biomass	CO_2	X	X	X	X
1.A.4 Other Sectors - Biomass	N_2O		X	X	
1.B.1 Fugitive emissions from Solid Fuels	CH_4	X	X	X	X
1.B.2.b Fugitive emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	X	X	X	X
2.A.1 Cement Production	CO_2	X	X	X	X
2.A.2 Lime Production	CO_2		X	X	X
2.A.4 Other Process Uses of Carbonates	CO_2	X		X	X
2.C.1 Iron and Steel Production	CO_2	X	X	X	X
2.F.6 Other Applications	F-gases	X	X	X	X
3.A Enteric Fermentation	CH_4	X	X	X	X
3.B Manure Management	CH_4	X	X	X	X
3.B Manure Management	N_2O	X	X	X	X
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	X	X	X	X
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	X	X	X	X
4.A.1 Forest Land Remaining Forest Land	CO_2	X	X		X
4.G Harvested Wood Products	CO_2	X	X		X
5.A Solid Waste Disposal	CH_4	X	X	X	X
5.D Wastewater Treatment and Discharge	CH_4	X	X	X	X
5.D Wastewater Treatment and Discharge	N_2O	X		X	

Note: L: Level assessment; T: Trend assessment

Based on the results of the key category analysis, it is tried to increase the Tiers in emissions/removals estimation. However due to resource restrictions, Tier 1 approaches have to be used for some key categories, such as CH_4 emissions from other sectors, solid fuels and oil and gas systems in energy sectors, CH_4 emissions from manure management, N_2O emissions from agricultural soils and wastewater treatment and discharge. Efforts to increase the tiers for all key categories are ongoing.

1.6. General Uncertainty Evaluation

For calculation of uncertainty, error propagation method (Approach 1) for combining uncertainties, as outlined in Volume 1 (Chapter 3) of the 2006 IPCC Guidelines for National GHG Inventories (2006 IPCC Guidelines) is used and general combined uncertainty is estimated with Approach 1.

The general procedures for uncertainty analysis based on the expert judgment are as follows;

- Uncertainties of each activity are allocated by using EFs and AD uncertainties,
- Emissions are estimated for each (CO_2, CH_4, N_2O, HFC, PFC and SF_6) gases,
- The uncertainties for industrial processes data are estimated by TurkStat,
- The uncertainties of F-gases data are estimated by MoEUCC,
- The uncertainties of agricultural activities data are estimated by TurkStat,
- The uncertainties of waste data are estimated by TurkStat,
- The uncertainties for sectoral energy usage data are estimated by MENR,
- The uncertainties of transport data are estimated by MoTI,
- The uncertainties of forestry and other land use data are estimated by MoAF.

Quantitative estimates of the uncertainties in the emissions are calculated using direct sectoral expert judgement based on the data collection matters considering completeness, accuracy and other parameters. The overall combined uncertainty with LULUCF is 8.9%, and 5.2% without LULUCF by means of Approach 1.

1.7. General Assessment of Completeness

Completeness by source and sink categories: The inventory is considered to be largely complete with only a few minor sources not estimated, due to either a lack of available information. These sources are considered to be insignificant, when compared with the inventory as a whole. The categories given in Annex 5 were not estimated due to insufficient data or methodology.

Completeness by geographical coverage: Geographical coverage of the inventory is complete. It includes all territories of Türkiye.

A complete set of CRT are provided for all years and estimates are calculated in a consistent manner.

Complete list of source/sink categories reported as “NE” and “IE” is given in Annex 5.

2. TRENDS IN GREENHOUSE GAS EMISSIONS

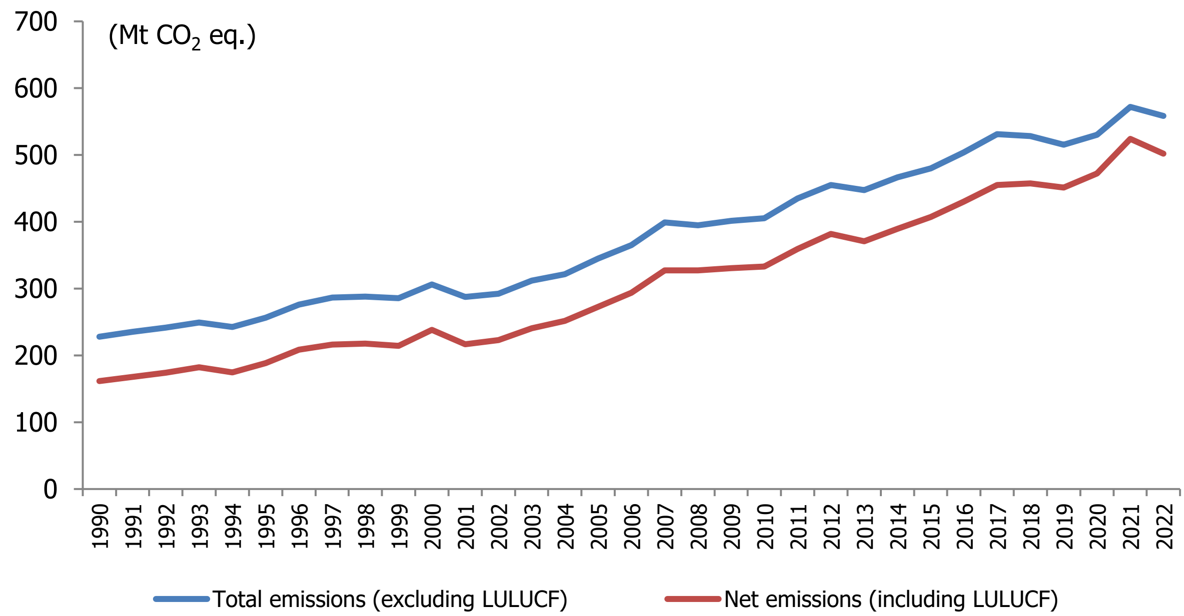
2.1. Emission Trends for Aggregated Greenhouse Gas Emissions

Total GHG emissions, excluding the LULUCF sector, were 558.3 Mt CO_2 eq. in 2022. This represents an increase of 330.3 Mt CO_2 eq. (144.9%) on total emissions in 1990 and a decrease of 13.7 Mt CO_2 eq. (2.4%) in 2021.

Net GHG emissions, including the LULUCF sector, were 502.2 Mt CO_2 eq. in 2022. This represents an increase of 340.6 Mt CO_2 eq. (210.8%) on total emissions in 1990 and a decrease of 21.9 Mt CO_2 eq. (4.2%) in 2021.

Figure 2.1 presents total and net GHG emissions from 1990 to 2022.

Figure 2.1 Emission trend for aggregated GHG emissions, 1990-2022



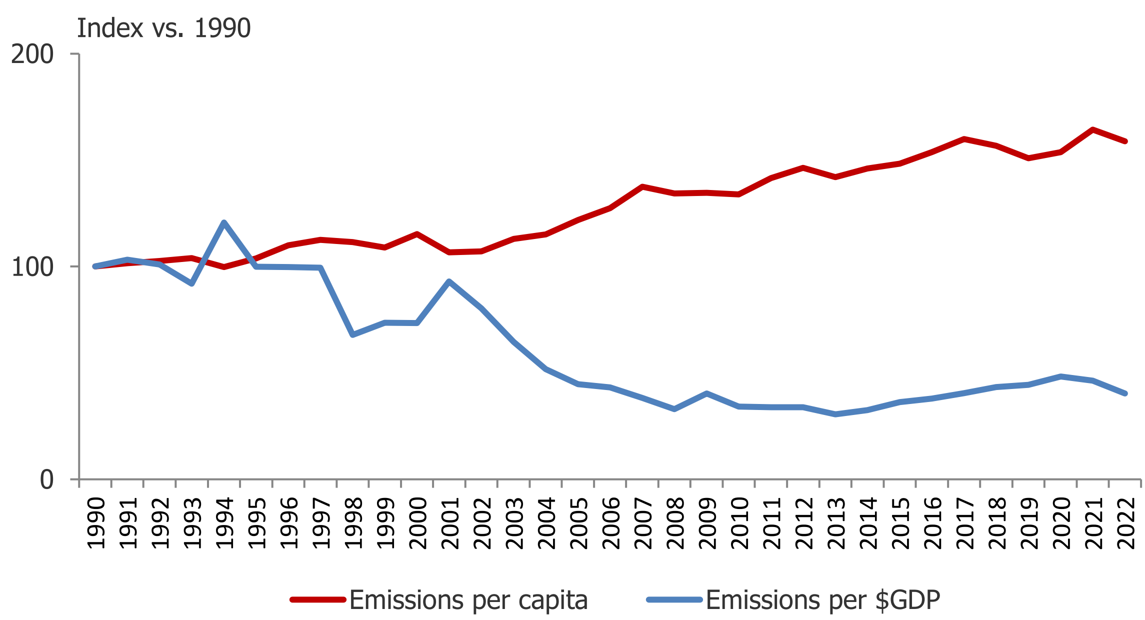
There is a positive trend in the total emissions over the period 1990-2022. However, economic recessions had directly caused reductions in the total GHG emissions in 1994, 1999, 2001, 2008, 2018 and 2019. In these years total emissions are decreased by 2.6%, 0.9%, 6.1%, 1%, 0.6% and 2.4% as compared to the previous year's emissions respectively. Although there is no economic recession total emissions are slightly decreased by 1.7% and 2.4% in 2013 and 2022 respectively.

The fluctuations in the emission trends are mainly due to the trends in economic activities. Therefore, GDP can be thought as the main driver of the GHG emissions in Türkiye. It has nearly the same pattern as total GHG emissions for the period 1990-2022. It reached 905.8 billion USD in 2022 from 149.2 billion USD in 1990.

Population is another driver of the emission trends in national inventories. The mid-year population of Türkiye increased about increased about 54.2% for the period 1990-2022. While it was 55.1 million in 1990, it reached 85 million in 2022. Accordingly, CO_2 eq. emissions per capita are 6.6 kt in 2022, while it was 4.1 kt in 1990.

Figure 2.2 shows trends on various statistics related to greenhouse gas emissions normalized to 1990 as a baseline year. These values represent the relative change (in comparison with base year for every year) in each statistic since 1990. The direction of the emissions per $ of GDP trend started to change after 2002, when GDP (in current price) began to peak, while emissions per capita continued to increase slightly.

Figure 2.2 Trends in emissions per capita and dollar of GDP relative to 1990



Source: https://data.tuik.gov.tr/Bulten/Index?p=Yillik-Gayrisafi-Yurt-Ici-Hasila-2023-53450

Table 2.1 gives summary data for GHG emissions for some selected years between 1990 and 2022.

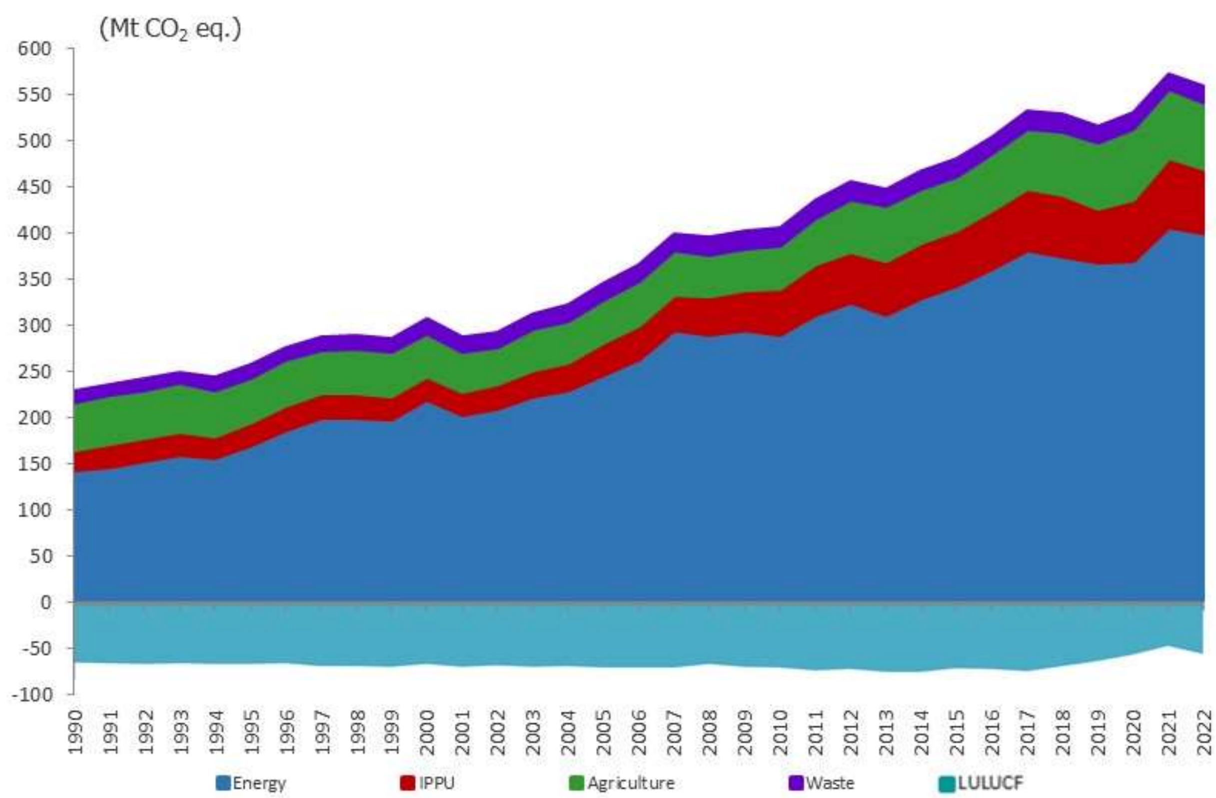
Table 2.1 Aggregated GHG emissions by sectors

(Mt CO_2 eq.)

Sector	**1990**	**2000**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Total (exc. LULUCF)	228.00	306.39	405.27	480.07	504.09	531.11	528.08	515.58	530.18	571.99	558.27
Energy	143.15	219.76	290.94	343.99	361.87	381.83	374.72	368.94	369.52	406.47	400.59
IPPU	22.69	26.05	48.57	59.16	63.20	66.08	67.15	58.35	67.24	74.72	69.91
Agriculture	51.85	46.03	47.68	59.21	61.69	66.33	68.91	71.52	76.44	75.38	71.51
Waste	10.32	14.54	18.08	17.72	17.32	16.87	17.30	16.77	16.98	15.42	16.26
LULUCF	-66.43	-68.16	-72.06	-72.86	-73.74	-76.03	-70.40	-64.30	-57.64	-47.87	-56.10
Comp. to 1990 (%)	-	34.38	77.75	110.56	121.09	132.94	131.61	126.13	132.53	150.87	144.85

In overall 2022 emissions excluding LULUCF, the energy sector had the largest portion with 71.8%. The energy sector was followed by the sectors of agriculture with 12.8%. IPPU with 12.5%, and waste with 2.9%. In Figure 2.3 fluctuations of whole sectors can be seen for the entire period starting with 1990.

Figure 2.3 GHG Emissions and sinks by sector, 1990-2022



2.2. Emission Trends by Gas

Total CO_2 emissions (excluding LULUCF) increased by 186.4% from 1990 to 2022. CH_4 emissions (excluding LULUCF) increased by 40.8% and N_2O emissions (excluding LULUCF) increased by 54.6%.

Total CO_2 emissions (including LULUCF) increased by 340% from 1990 to 2022. There are no significant changes in other GHGs by taking into account the LULUCF sector. CH_4 emissions (including LULUCF) increased by 40.7% and N_2O emissions (including LULUCF) increased by 54.6%.

As shown in Figure 2.4, the CO_2 emissions show a general increasing trend, while N_2O and CH_4 emissions are not changing considerably.

Figure 2.4 Emission trend of main GHGs, 1990-2022

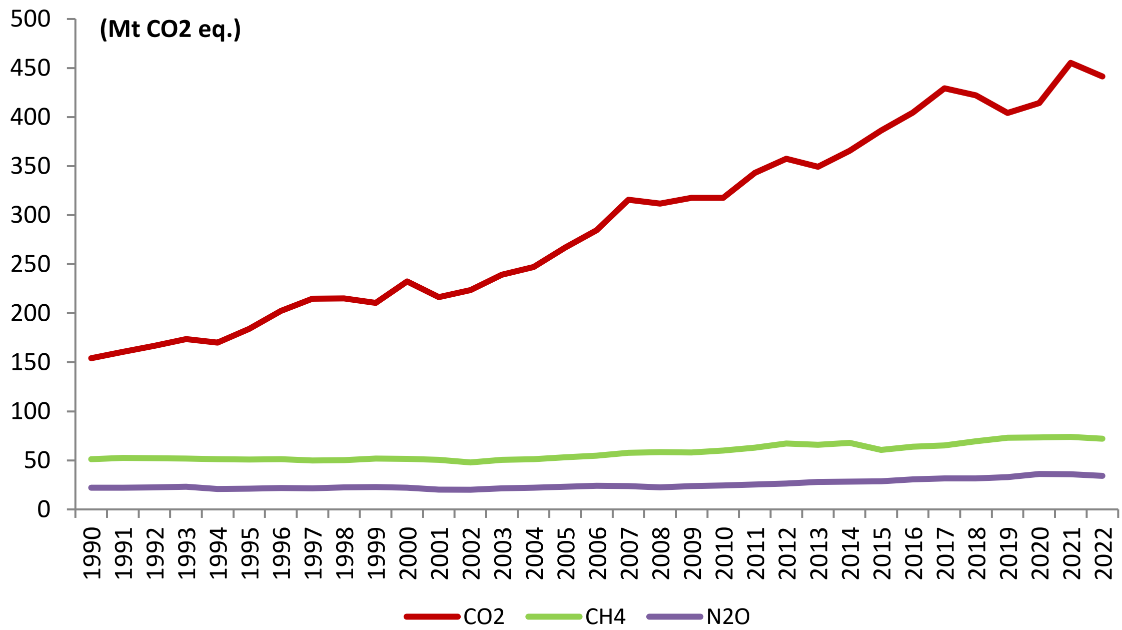


Table 2.2 gives summary data for GHG emissions by gas for some selected years between 1990 and 2022.

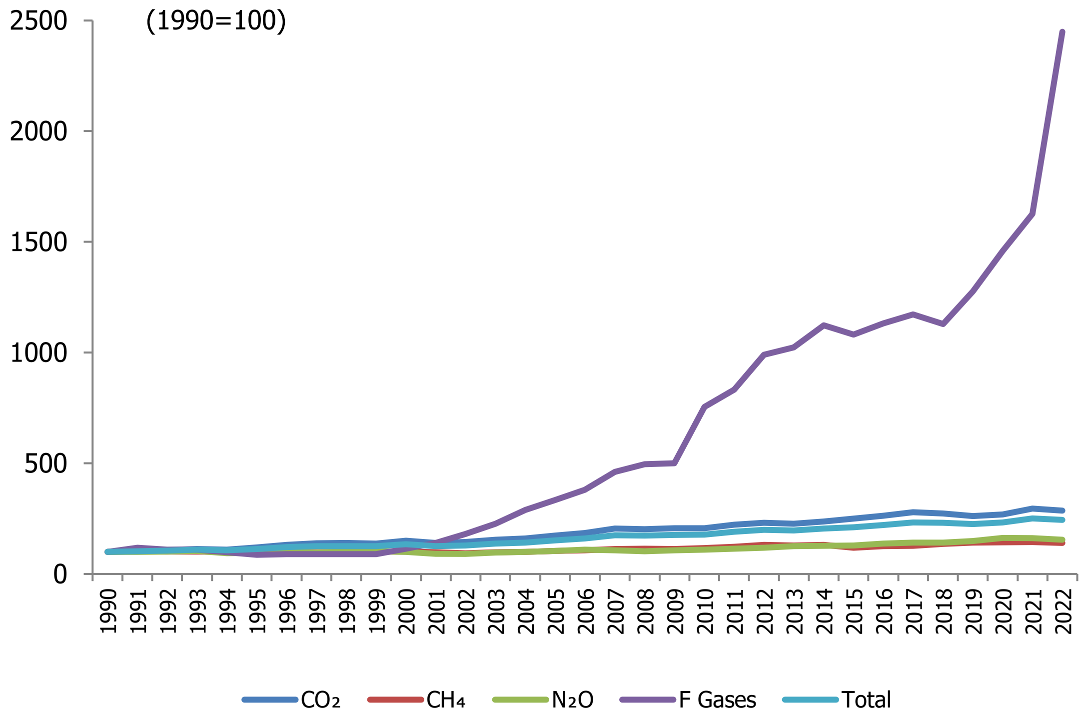
Table 2.2 Aggregated GHG emissions excluding LULUCF

(Mt CO_2 eq.)

Gas	1990	2000	2010	2015	2016	2017	2018	2019	2020	2021	2022
Total	228.00	306.39	405.27	480.07	504.09	531.11	528.08	515.58	530.18	571.99	558.27
CO_2	154.14	232.35	317.56	386.32	404.65	429.35	422.15	404.30	414.38	455.25	441.42
CH_4	51.26	51.53	60.06	60.54	64.09	65.26	69.59	72.96	73.49	73.92	72.16
N_2O	22.18	22.02	24.45	28.62	30.54	31.52	31.55	32.90	36.11	35.92	34.29
HFCs	NO	0.11	2.79	4.42	4.69	4.83	4.65	5.25	6.01	6.72	10.18
PFCs	0.42	0.37	0.35	0.08	0.03	0.02	0.01	0.02	0.01	0.01	0.01
SF_6	NO	0.01	0.07	0.08	0.08	0.12	0.14	0.16	0.17	0.18	0.21

Figure 2.5 shows trends in the index for each year compared to previous year by gas for the 1990-2022 period. 1990 is assumed as "100" for indexing. All gases are showing an increasing trend compared to 1990 and also to previous years in general. The sharpest trend belongs to F Gases since they increased by 2 449% in proportion to 1990.

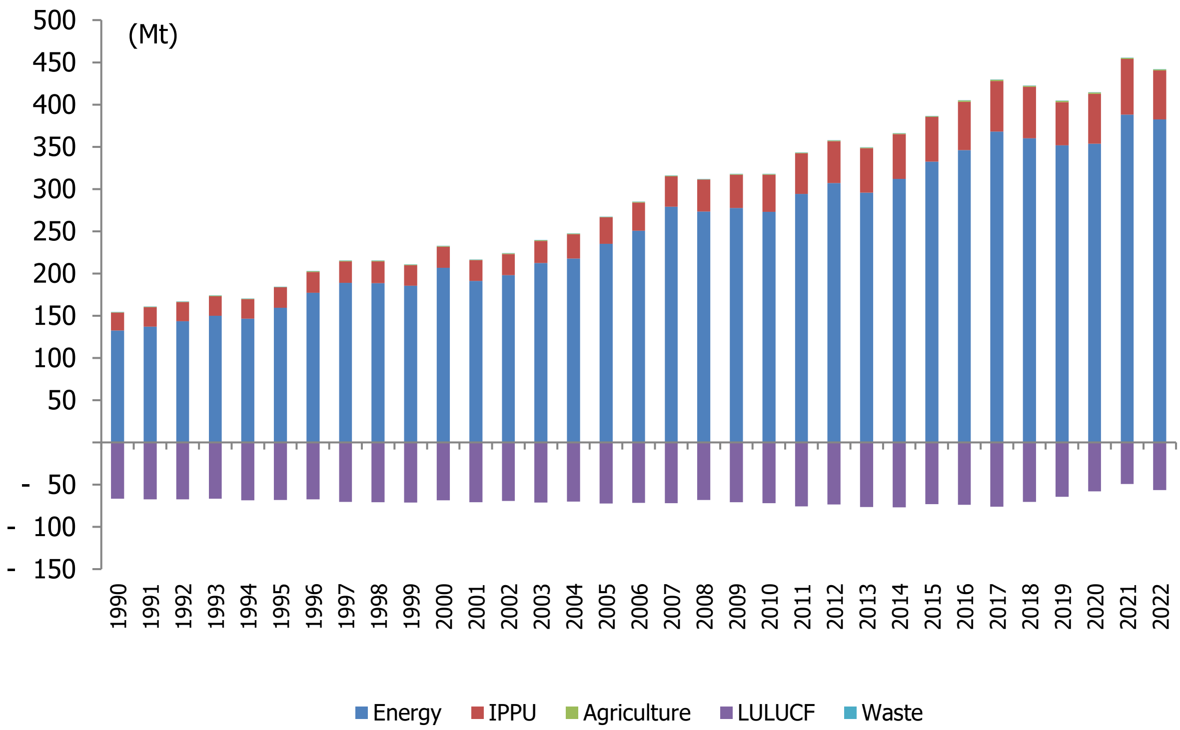
Figure 2.5 Trends in emissions by gas relative to 1990



Carbon Dioxide (CO_2)

In 2022, CO_2 emissions are 441.4 Mt (excluding LULUCF), 3% below the 2021 level and 186.4% above the 1990 level. Figure 2.6 illustrates the trend in CO_2 emissions. It is seen that CO_2 emissions are dominated by the energy sector which is the main driver for the rising trend in emissions. This situation is caused by the growing industrial sector and population in Türkiye. In 2022 excluding the LULUCF, the energy sector is responsible for 86.6% of the total CO_2 emissions while IPPU is responsible for 13.1%. The agriculture and waste sectors do not cause a significant amount of CO_2 emission.

Figure 2.6 CO_2 emissions by sector, 1990-2022

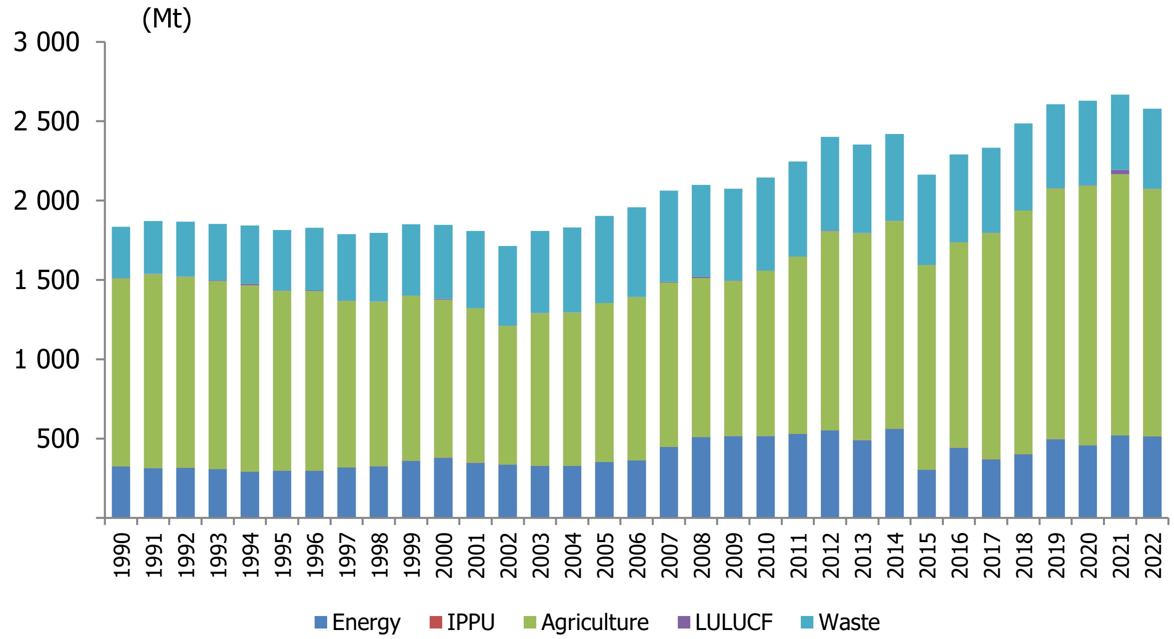


Methane (CH_4)

The trend in emissions of CH_4 is broken down by source in Figure 2.7, CH_4 is the second most significant GHG after CO_2 in Türkiye since 1990. Emissions of CH_4 have increased by 40.8% since the base year 1990 and have decreased by 2.4% compared to 2021. In 2022, CH_4 emissions were 2 577 kt excluding the LULUCF.

The major sectors of CH_4 are enteric fermentation from agriculture, solid waste disposal from the waste sector and fugitive emissions in the energy sector. Emissions from IPPU and LULUCF are not significant sources of CH_4 in comparison with other sectors. Generally, all sectors have risen since 1990.

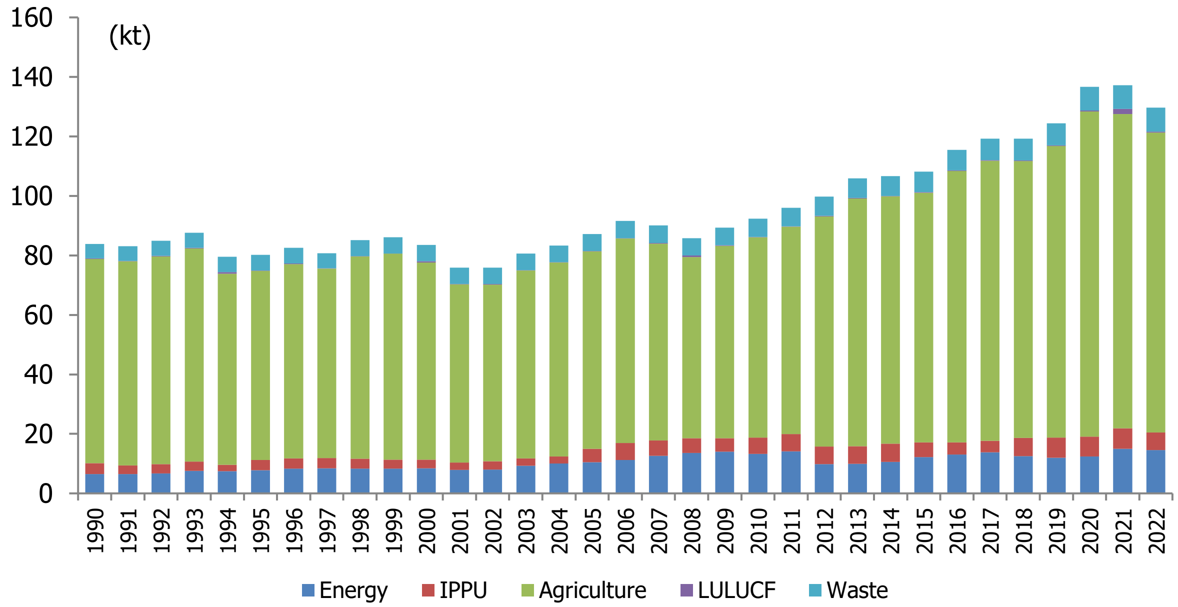
Figure 2.7 CH_4 emissions by sector, 1990-2022



Nitrous Oxide (N_2O)

In 2022, N_2O emissions are 129 kt without LULUCF and it decreased by 4.5% compared to 2021. As it is seen from Figure 2.8, the agriculture sector is the main contributor of N_2O emissions in all the years and the share is 77.9% in 2022. The energy sector is responsible for 11.2% and waste sector is responsible for 6.2% of all N_2O emissions. IPPU has a minor share of the N_2O emissions by 4.6%.

Figure 2.8 N_2O emissions by sector, 1990-2022



Fluorinated Gases (HFCs, PFCs, SF_6)

The F-gases are only caused by the IPPU sector. In 2022, 10 400 kt CO_2 eq. of F-gases released to the atmosphere. It is seen from Table 2.3 that total F-gas emissions increased by 2 349% since 1990. The main contributor to total F-gas emissions is HFCs emissions and it is mainly the results of efforts to phase out CFCs and other ODS under the provisions of the Montreal Protocol. Additionally increasing demand of refrigerant and air conditioning sector are also responsible for the rising trend of HFCs emissions in Türkiye.

Emission values of PFCs, CF_4 and C_2F_6 decreased after 2015, compared to previous years due to the change of aluminium production system from Søderberg to Prebaked smelted in 2015. There has been a decreasing trend in the number of anode effects after switching to prebaked smelter system.

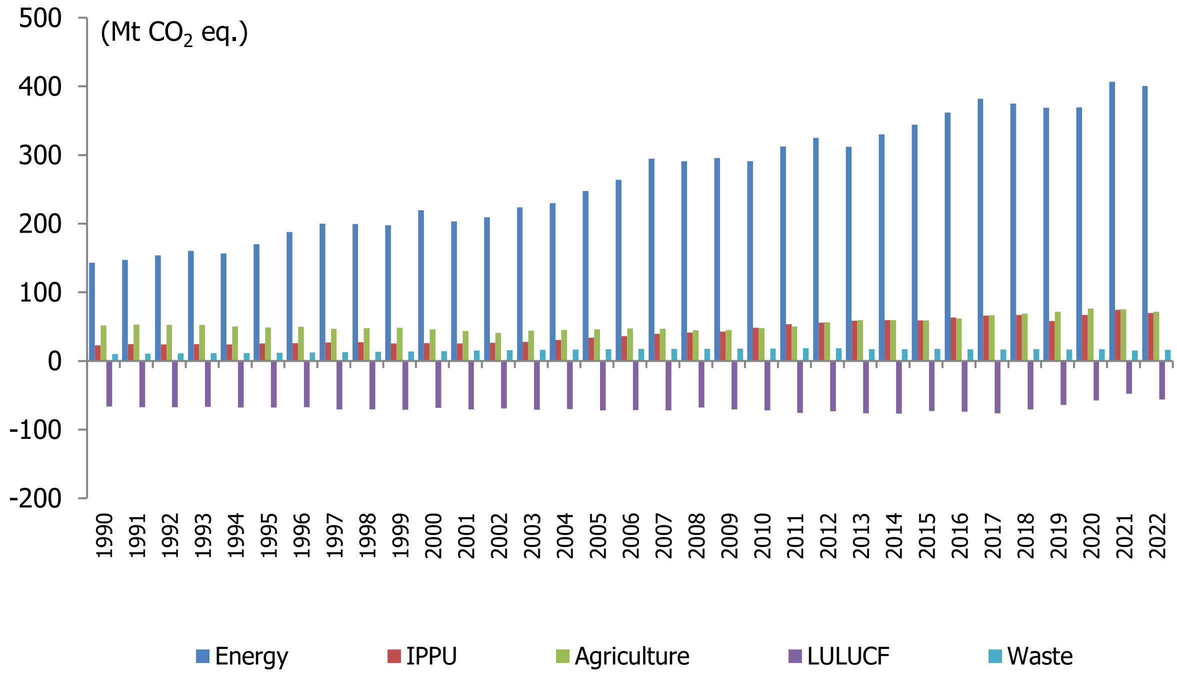
Table 2.3 Fluorinated gases emissions, 1990-2022

(kt CO_2 eq.)

Year	HFCs	PFCs	SF_6
1990	NO	424.66	NO
2000	105.20	367.58	13.75
2010	2 789.30	348.10	66.62
2015	4 424.80	82.06	83.47
2016	4 694.11	33.61	81.08
2017	4 831.65	22.64	124.21
2018	4 646.72	9.08	138.23
2019	5 248.96	15.38	158.88
2020	6 008.26	9.34	174.84
2021	6 716.13	6.11	182.17
2022	10 184.05	7.73	208.35

2.3. Emission Trends by Sector

Figure 2.9 GHG emission trend by sectors, 1990-2022



1990-2022: Out of decreasing trend of LULUCF sector (15.6%) all sectors have an increasing trend from 1990 to 2022 including energy (180%), IPPU (208%), waste (58%) and agriculture (38%).

The main reasons for the increasing sectors are population growth, a growing economy and an increase in energy demand.

The main reasons for the rise in removals of LULUCF are improvements in sustainable forest management, afforestation, rehabilitation of degraded forests, reforestations on forest land and conversion of coppices to productive forests in forest land remaining forest land, efficient forest fire management and protection activities, conversions to perennial croplands from annual croplands and grasslands, and conversions to grasslands from annual croplands. The main reasons for the decrease in removals of LULUCF are related to drought and biomass burning as wildfire (e.g. in the year 2008; 29.7 kha forest area, in the year 2021; 134.8 kha forest area burned), intense harvest policies, deforestation, conversions to wetlands (flooded land) and settlements.

2021-2022: There are increasing and decreasing trends in the annual change for the sectors. The sectors having increasing trends are LULUCF (17.2%) and waste (5.5%) sectors while energy (1.4%), IPPU (6.4%) and agriculture (5.1%) have decreased from 2021 to 2022.

In the energy sector; energy industries (2.1%), manufacturing industries and construction (4.5%) have decreased while transport (0.9%) and fugitive emissions from fuels (0.8%) have increased in 2022.

The detailed reasons behind the emission trends and main drivers for all sectors are discussed by each sub-sector in the related chapters.

While Table 2.4 provides a contribution of sectors to the net GHG emissions by sectors for some selected years between 1990 and 2022, Table 2.5 shows the same shares for the GHG emissions without LULUCF.

Table 2.4 Contribution of sectors to the net GHG emissions

(%)

Sectors	**1990**	**2000**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Energy	88.60	92.25	87.31	84.47	84.09	83.90	81.88	81.75	78.20	77.55	79.77
IPPU	14.04	10.94	14.58	14.53	14.69	14.52	14.67	12.93	14.23	14.26	13.92
Agriculture	32.09	19.32	14.31	14.54	14.33	14.58	15.06	15.85	16.18	14.38	14.24
Waste	6.38	6.10	5.43	4.35	4.03	3.71	3.78	3.72	3.59	2.94	3.24
LULUCF	-41.11	-28.61	-21.63	-17.89	-17.13	-16.71	-15.38	-14.25	-12.20	-9.13	-11.17

Table 2.5 Contribution of sectors to the GHG emissions without LULUCF

(%)

Sectors	**1990**	**2000**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Energy	62.78	71.73	71.79	71.65	71.79	71.89	70.96	71.56	69.70	71.06	71.75
IPPU	9.95	8.50	11.99	12.32	12.54	12.44	12.72	11.32	12.68	13.06	12.52
Agriculture	22.74	15.02	11.76	12.33	12.24	12.49	13.05	13.87	14.42	13.18	12.81
Waste	4.52	4.74	4.46	3.69	3.44	3.18	3.28	3.25	3.20	2.70	2.91

Energy

As in most countries, the energy system in Türkiye is largely driven by fuel combustion, followed by fugitive emissions from fuels and then CO_2 transport and storage. In 2022, emissions from the energy sector are 71.8% of total emissions, excluding LULUCF. Emissions in CO_2 eq. from the energy sector are reported in Table 2.6 and shown in Figure 2.10.

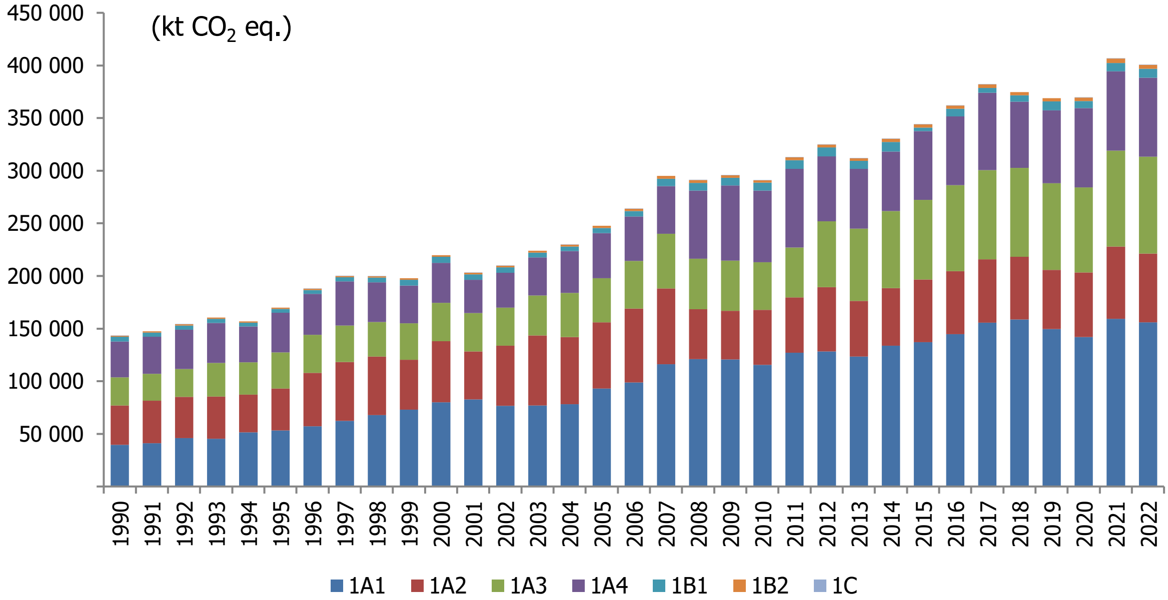
CO_2 emissions, 95.5% of the total energy sector emissions, showed an increase of increase of 188.9% from 1990 to 2022. CH_4 emissions are just 3.6% of the total, increased by 58.4% in comparison with 1990. N_2O emissions, with a 1% contribution to total emissions of the energy sector, show a 122.1% increase in proportion to the year 1990.

Table 2.6 Total emissions from the energy sector by source

(kt CO_2 eq.)

	1990	2000	2010	2015	2016	2017	2018	2019	2020	2021	2022
Total	143 147	219 764	290 938	343 985	361 871	381 828	374 723	368 938	369 521	406 472	400 586
1.A Fuel combustion	137 752	212 388	281 078	337 584	351 652	373 976	365 655	357 400	359 344	394 390	388 408
1.A.1 Energy industries	39 701	80 116	115 387	136 984	144 592	155 663	158 626	149 585	141 859	159 351	155 937
1.A.2 Manufacturing industries and construction	37 157	57 928	52 326	59 578	60 064	60 174	59 595	56 150	61 593	68 537	65 463
1.A.3 Transport	26 912	36 408	45 346	75 713	81 749	84 670	84 518	82 334	80 585	91 087	91 866
1.A.4 Other sectors	33 982	37 936	68 020	65 310	65 247	73 469	62 916	69 331	75 307	75 415	75 142
1.B Fugitive emissions from fuels	5 395	7 376	9 860	6 401	10 219	7 853	9 068	11 537	10 177	12 082	12 178
1.B.1 Solid fuels	4 401	5 930	7 554	3 324	7 215	4 492	5 979	8 305	6 814	7 969	8 332
1.B.2 Oil and natural gas	994	1 446	2 306	3 076	3 005	3 360	3 089	3 232	3 362	4 113	3 846
1.C CO_2 transport and storage	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13

Figure 2.10 Trend of total emissions from the energy sector, 1990-2022



GHG emissions of the energy sector, in CO_2 eq., show an increase of 179.8% from 1990 to 2022. Generally, an upward trend is noted from 1990 to 2022.

IPPU

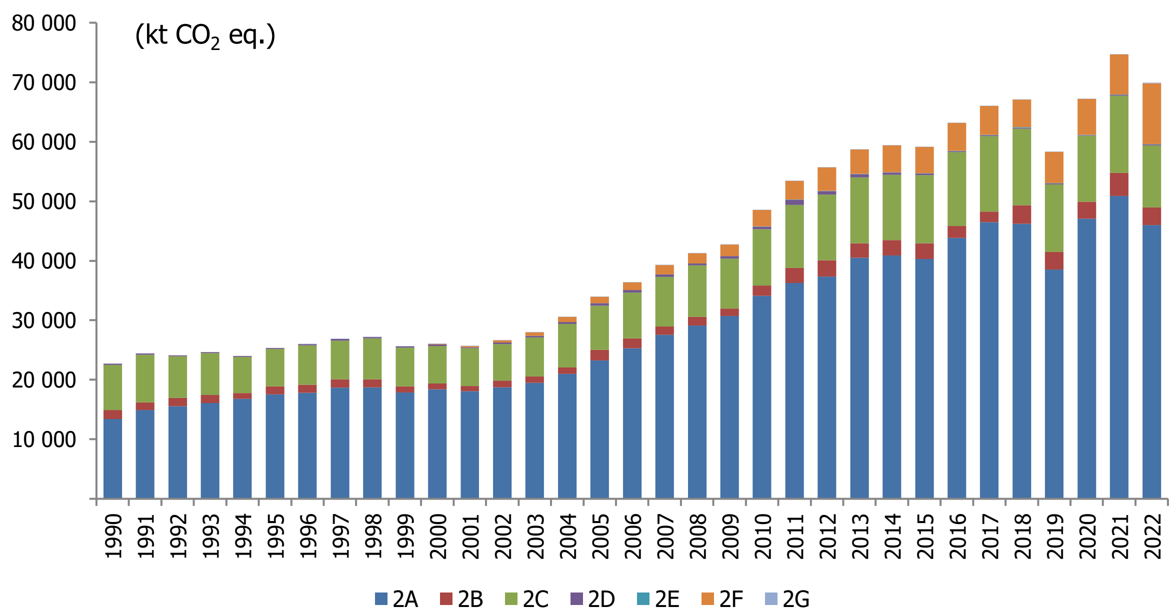
Emissions from the industrial process and product use sector have a share of 12.5% of Türkiye's total emissions excluding LULUCF in 2022. CO_2 emissions are 82.8% of total IPPU emissions in 2022. N_2O and CH_4 have a minor impact on IPPU emissions and N_2O increased by 67.1% compared to 1990. Emissions by each subsector of IPPU are tabulated in Table 2.7 for the 1990-2022 period. Figure 2.11 shows the trend for the IPPU related emissions by cumulating its subsectors.

Table 2.7 Total emissions from the industrial process and product use sector by source

(kt CO_2 eq.)

	1990	2000	2010	2015	2016	2017	2018	2019	2020	2021	2022
Total	22 691	26 054	48 575	59 160	63 203	66 077	67 148	58 355	67 241	74 715	69 908
2.A Mineral industry	13 424	18 418	34 087	40 305	43 821	46 474	46 213	38 548	47 064	50 875	46 010
2.B Chemical industry	1 511	968	1 720	2 631	2 024	1 769	3 144	2 921	2 868	3 913	2 944
2.C Metal industry	7 573	6 273	9 480	11 450	12 437	12 731	12 806	11 382	11 049	12 911	10 458
2.D Non-energy products from fuels and solvent use	183	277	432	266	146	152	206	138	134	170	148
2.E Electronic industry	NO	NO	44	44	44	47	59	59	60	67	71
2.F Product uses as ODS substitutes	NO	105	2 789	4 425	4 694	4 832	4 647	5 249	6 008	6 716	10 184
2.G Other product manufacture and use	NO,NE	14	23	40	37	73	73	58	57	64	94

Figure 2.11 Trend of total emissions from IPPU sector, 1990-2022



IPPU related emissions increased by 208.1% from 1990 to 2022. Due to the growth of population and production especially for the recent decade, emissions from the IPPU sector are increased.

Agriculture

Enteric fermentation is by far the largest source of GHG emissions of agriculture in Türkiye since 1990. The agriculture sector includes emissions from enteric fermentation, manure management, rice cultivation, agricultural soils, field burning of agricultural residues and urea application. In 2022, the agriculture sector accounted for 12.8% of total emissions in Türkiye. Enteric fermentation and agricultural soils dominate the trends in this sector between 1990 and 2022 as seen in Table 2.8 and they have an increase of 27.5% and 45% compared to 1990 respectively.

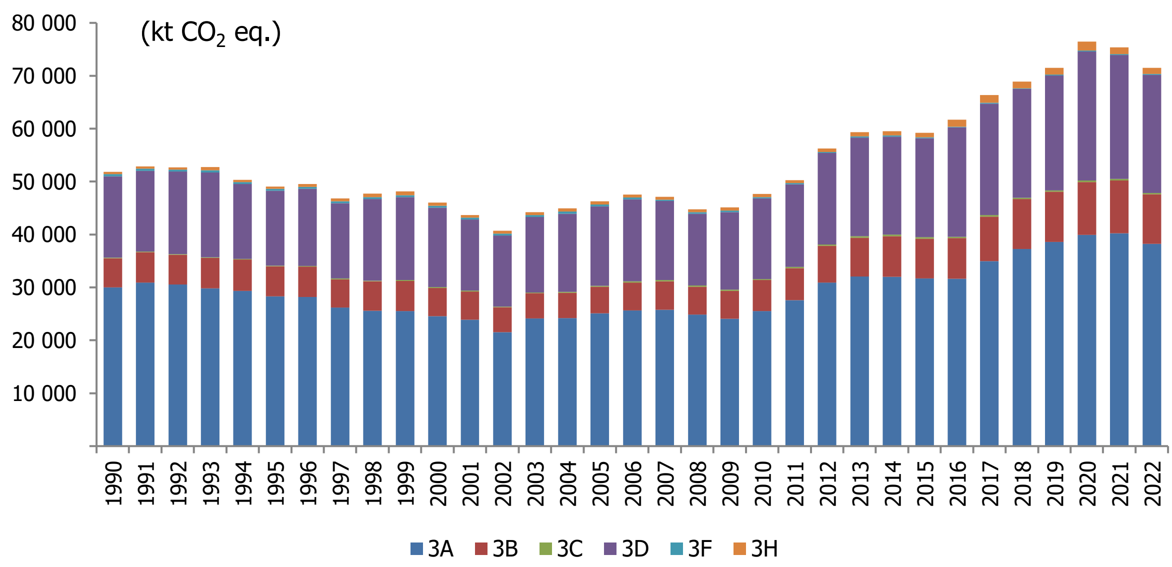
The most important portion in each gas is CH_4 with 61% then comes N_2O with 37.4% share in the agriculture sector emissions. CO_2 has the lowest contribution with 1.6%.

Table 2.8 Total emissions from the agriculture sector by source

(kt CO_2 eq.)

	1990	2000	2010	2015	2016	2017	2018	2019	2020	2021	2022
Total	51 848	46 033	47 678	59 208	61 690	66 329	68 910	71 517	76 437	75 376	71 512
3.A Enteric fermentation	29 996	24 575	25 498	31 685	31 617	34 987	37 248	38 608	39 953	40 210	38 244
3.B Manure management	5 518	5 334	5 880	7 531	7 696	8 412	9 425	9 454	9 934	9 998	9 349
3.C Rice cultivation	112	143	226	269	272	262	282	294	293	302	280
3.D Agricultural soils	15 391	15 001	15 195	18 728	20 635	21 043	20 523	21 698	24 417	23 396	22 318
3.F Field burning of agricultural residues	370	362	233	185	175	176	173	176	183	169	182
3.H Urea application	460	617	645	811	1 295	1 450	1 257	1 288	1 657	1 302	1 138

Figure 2.12 Trend of total emissions from agriculture sector, 1990-2022



LULUCF

GHG emissions of the LULUCF sector from sources and removals by sinks are estimated and reported for categories of managed lands: forest land, cropland, grassland, wetlands, settlements, harvested wood products, other land and others.

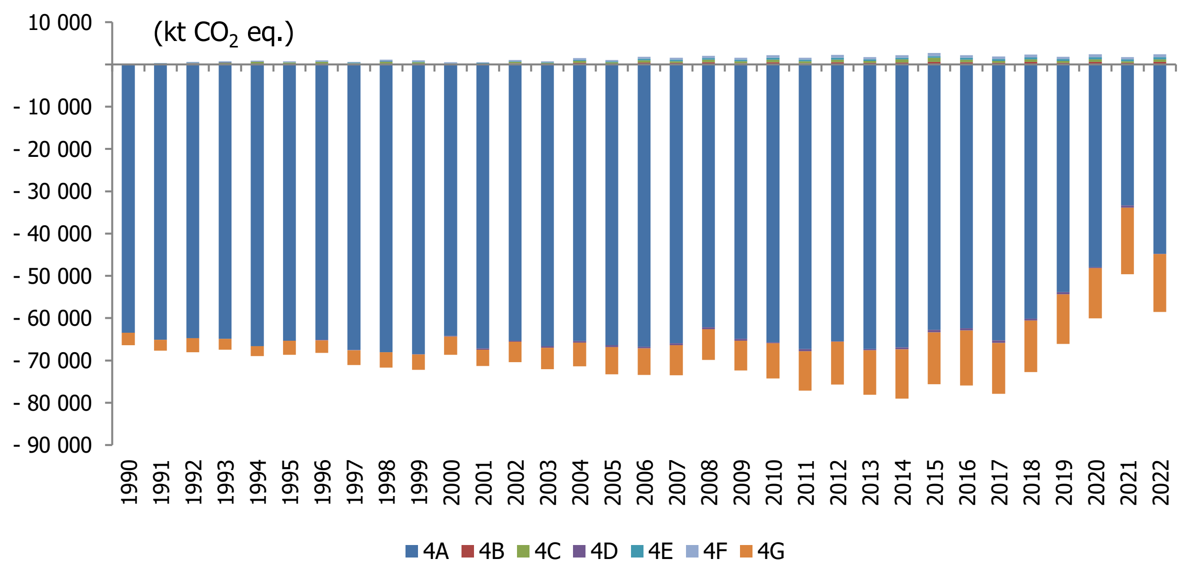
In 2022, total CO_2 eq. removals of the LULUCF sector have increased by 17.2% compared to 2021. Table 2.9 reports emissions and removals from the LULUCF sector by source.

Table 2.9 Total emissions and removals from the LULUCF sector by source

(kt CO_2 eq.)

	1990	2000	2010	2015	2016	2017	2018	2019	2020	2021	2022
Total	-66 430	-68 156	-72 058	-72 857	-73 736	-76 034	-70 402	-64 302	-57 641	-47 875	-56 096
4.A Forest land	-63 482	-64 183	-65 691	-62 751	-62 383	-65 286	-60 082	-53 816	-47 924	-33 379	-44 755
4.B Cropland	IE,NE,NO	65	530	578	524	408	583	352	585	373	574
4.C Grassland	NA,NO	94	630	977	573	417	602	487	645	383	628
4.D Wetlands	-0.03	- 158	- 231	- 644	- 544	- 603	- 498	- 528	- 260	- 519	- 98
4.E Settlements	IE,NO	144	424	419	473	470	478	454	513	478	509
4.F Other land	NO	187	600	764	619	586	650	532	695	533	735
4.G Harvested wood products	-2 948	-4 305	-8 321	-12 198	-12 998	-12 027	-12 135	-11 783	-11 895	-15 744	-13 689

Figure 2.13 Trend of total emissions from the LULUCF sector, 1990-2022



LULUCF emissions or removals, in CO_2 equivalent, are variable over the reporting period 1990-2022 as seen in Figure 2.13. Generally, decreases in removals were influenced by fires and drought in the relevant areas. Moreover, rises are originated mainly from forest management, afforestation, rehabilitation of degraded forests, reforestations on forest land, etc.

Waste

The waste sector includes GHG emissions from the treatment and disposal of wastes, open burning, wastewater treatment and discharge. Waste incineration emissions are included in the inventory however it is reported under the energy sector. The waste sector GHG emissions are tabulated in Table 2.10. Total waste emissions for the year 2022 are 2.9% of total GHG emissions (without LULUCF). Considering emissions by gas the most important GHG is CH_4 which accounts for 86.8% of the total and shows an increase of an increase of 57% from 1990 to 2022. N_2O levels have increased by 65.1% whereas CO_2 decreased by -79.6% from 1990 to 2022; these gases account for 13.2% and less than 0.01% share in the waste sector.

Table 2.10 Total emissions from the waste sector by source

(kt CO_2 eq.)

	1990	2000	2010	2015	2016	2017	2018	2019	2020	2021	2022
Total	10 316	14 537	18 078	17 722	17 325	16 873	17 297	16 773	16 976	15 424	16 265
5.A Solid waste disposal	5 788	9 590	13 080	13 140	12 687	12 109	12 201	11 625	11 642	9 922	10 613
5.B Biological treatment of solid waste	13	13	21	16	16	14	18	19	16	23	20
5.C Incineration and open burning of waste	110	93	39	2	4	3	3	5	8	10	12
5.D Wastewater treatment and discharge	4 405	4 841	4 937	4 563	4 619	4 746	5 076	5 124	5 311	5 469	5 620

Figure 2.14 Trend of total emissions from the waste sector, 1990-2022

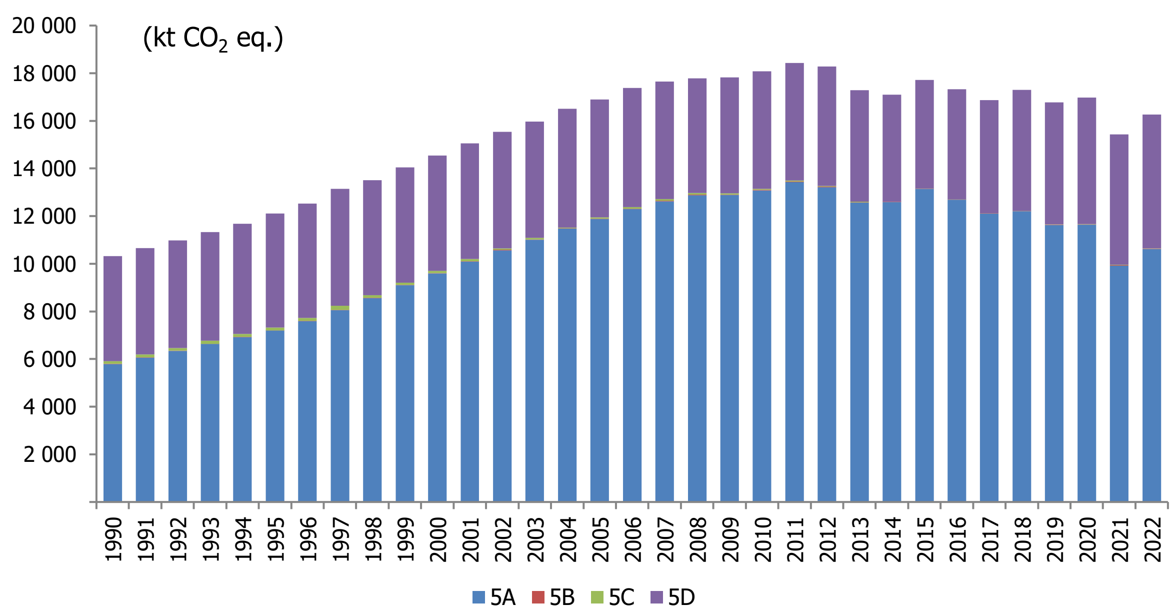


Figure 2.14 shows trends in the waste sector between 1990-2022. The trend is mainly driven by solid waste disposal where 65.2% of the emissions were from, followed by 5.D Wastewater treatment and discharge where 34.6% from, 0.13% from 5.B Biological treatment of solid waste and 0.07% from 5.C Incineration and open burning of waste. Total emissions, in CO_2 equivalent, increased by 5.5% from 2021 to 2022.

2.4. Emission Trends for Indirect Greenhouse Gases

Emission trends of NO_X, CO, NMVOC, SO_2 and NH_3 from 1990 to 2022 are given in Table 2.11.

Table 2.11 Total emissions for indirect greenhouse gases, 1990-2022

(kt)

Gas	1990	2000	2010	2015	2016	2017	2018	2019	2020	2021	2022
NO_X	124	1 262	979	961	993	973	959	971	956	981	983
CO	886	7 660	3 333	2 366	2 353	2 194	1 660	1 749	1 910	1 890	1 593
NMVOC	727	1 447	1 104	1 095	1 105	1 132	1 109	1 137	1 177	1 174	1 142
SO_X	560	710	2 473	1 959	2 274	2 379	2 528	2 533	2 310	2 700	2 738
NH_3	88	96	62	50	45	43	43	46	46	39	27

1990-2022: While four indirect gases have an increasing trend from 1990 to 2022 including NO_X (692%), SO_X (389%), NMVOC (57%) and CO (80%), NH_3 (70%) has a decreasing trend.

2021-2022: There are both increasing and decreasing trends in the annual change for each gas from 2021 to 2022. The gases having increasing trends are NO_X (0.2%) and SO_X (1.4%) while the gases that have decreasing trends are NMVOC (2.7%), CO (15.7%) and NH3 (31.3%).

3. ENERGY (CRT Sector 1)

3.1. Sector Overview

The energy sector includes emissions from the combustion of fossil fuels (1.A.1 energy industries; 1.A.2 manufacturing industries and construction; 1.A.3 transport; and 1.A.4 other sectors; as well as fugitive emissions from fossil fuels (1.B) and CO_2 transportation and storage (1.C).

Energy sector is the major source of Turkish anthropogenic GHG emissions. In overall 2022 GHG emissions (excluding LULUCF), the energy sector had the largest portion with 71.8%.

Energy sector CO_2 emissions constituted 86.6% of total CO_2 emissions in 2022. The non-CO_2 emissions from energy-related activities represented rather small portion of the total national emissions. CH_4 emissions are 19.9% of total national CH_4 emissions and N_2O emissions are 11.2% of total N_2O emissions in 2022.

Total emissions from the energy sector for 2022 were estimated to be 400.6 Mt CO_2 eq. (Table 3.1) Energy industries were the main contributor, accounting for 38.9% of emissions from the energy sector. It is followed by transport sector with 22.9%, other sector with 18.8% and manufacturing industries with 16.3% (Table 3.2).

Energy sector GHG emissions increased by 179.8% between 1990 and 2022 whereas annual emissions from 2021 to 2022 decreased by 1.44% (5 886 Kt CO_2 eq.).

Table 3.1 Energy sector emissions by gas, 1990-2022

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	132 343	324	6,5	143 147
1995	159 578	297	7,8	169 979
2000	206 908	379	8,5	219 764
2005	235 040	352	10,5	247 665
2010	273 010	515	13,2	290 938
2011	294 044	530	14,1	312 625
2012	306 909	551	9,8	324 946
2013	295 592	490	9,9	311 927
2014	311 820	561	10,6	330 350
2015	332 251	303	12,2	343 985
2016	346 060	442	13,0	361 871
2017	367 847	369	13,8	381 828
2018	360 174	401	12,5	374 723
2019	351 890	496	12,0	368 938
2020	353 470	456	12,4	369 521
2021	387 950	519	15,0	406 472
2022	382 368	513	14,5	400 586

Table 3.2 Energy sector GHG emissions, 1990-2022

(kt CO_2 eq.)

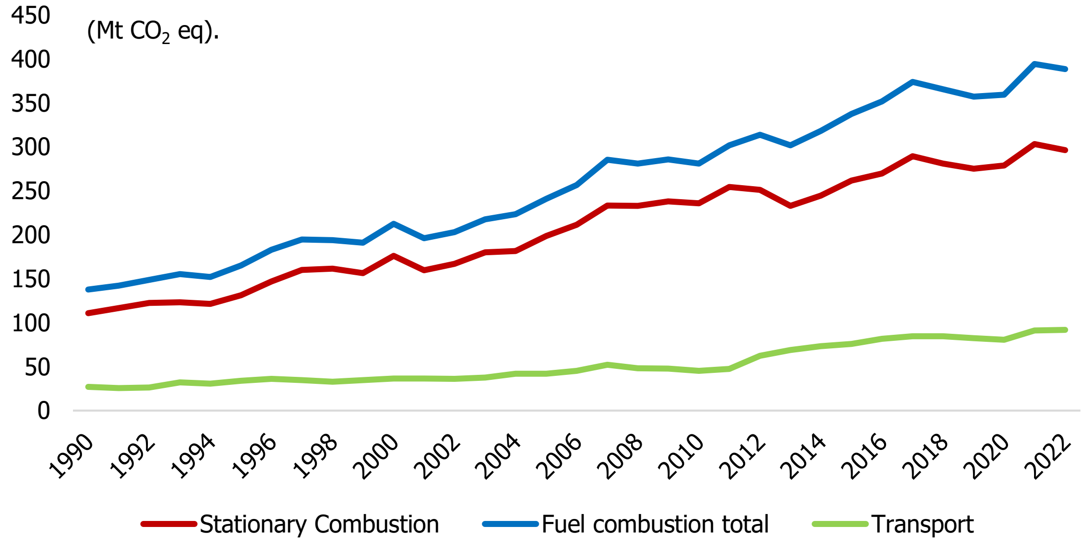
		Fuel combustion					Fugitive emissions from fuels			
Year	Energy	Fuel combustion total	Energy industries	Manufacturing industries and construction	Transport	Other sectors	Total fugitive emissions	Solid fuels	Oil and natural gas	CO_2 transport and storage
1990	143 147	137 752	39 701	37 157	26 912	33 982	5 395	4 401	994	0.13
1995	169 979	165 187	53 199	39 990	34 041	37 957	4 791	3 654	1 137	0.13
2000	219 764	212 388	80 116	57 928	36 408	37 936	7 376	5 930	1 446	0.13
2005	247 665	240 836	93 006	62 996	41 980	42 853	6 829	4 818	2 012	0.13
2010	290 938	281 078	115 387	52 326	45 346	68 020	9 860	7 554	2 306	0.13
2011	312 625	301 777	127 040	52 579	47 339	74 820	10 848	8 175	2 673	0.13
2012	324 946	313 728	128 300	61 045	62 456	61 927	11 217	8 401	2 817	0.13
2013	311 927	301 746	123 322	52 972	68 787	56 665	10 181	7 735	2 445	0.13
2014	330 350	318 154	133 897	54 433	73 474	56 350	12 196	8 968	3 228	0.13
2015	343 985	337 584	136 984	59 578	75 713	65 310	6 401	3 324	3 076	0.13
2016	361 871	351 652	144 592	60 064	81 749	65 247	10 219	7 215	3 005	0.13
2017	381 828	373 976	155 663	60 174	84 670	73 469	7 853	4 492	3 360	0.13
2018	374 723	365 655	158 626	59 595	84 518	62 916	9 068	5 979	3 089	0.13
2019	368 938	357 400	149 585	56 150	82 334	69 331	11 537	8 305	3 232	0.13
2020	369 521	359 344	141 859	61 593	80 585	75 307	10 177	6 814	3 362	0.13
2021	406 472	394 390	159 351	68 537	91 087	75 415	12 082	7 969	4 113	0.13
2022	400 586	388 408	155 937	65 463	91 866	75 142	12 178	8 332	3 846	0.13

Energy sector GHG emissions mainly are coming from stationary combustion. Total emissions from stationary combustion are 296.5 Mt CO_2 eq. in 2022, equal to 53.1% of total national GHG emissions (excluding LULUCF).

The energy industries subsector (1.A.1) contributed 155.9 Mt CO_2 eq. in 2022 while the GHG emissions from manufacturing industries and construction subsector (1.A.2) emissions were 65.4 Mt CO_2 eq. and GHG emissions from other sectors (1.A.4) were 75.1 Mt. The transport sector GHG emissions were 91.9 Mt in the same year.

GHG emissions from stationary combustion increased by 155% (180.3 Mt CO_2 eq.) between 1990 and 2022, and decreased by 5.6% (18.8 Mt CO_2 eq.) between 2021 and 2022.

Figure 3.1 GHG emissions from fuel combustion, 1990-2022



In 2022, transport contributed 92 Mt CO_2 eq., which is 16.5% of total GHG emissions (excluding LULUCF). The major source of transport emissions in Türkiye is road transportation. It accounts for 94% of transport emissions. It is followed by domestic aviation while other sources are far smaller: domestic aviation with 3.7% and domestic navigation with 1.2%. Pipeline transport contribution was 0.5% and railway contribution was 0.5%.

Fuel used in international aviation and marine bunkers is reported separately from the national total. In 2022, international bunker GHG emissions were 14.5 Mt CO_2 eq.

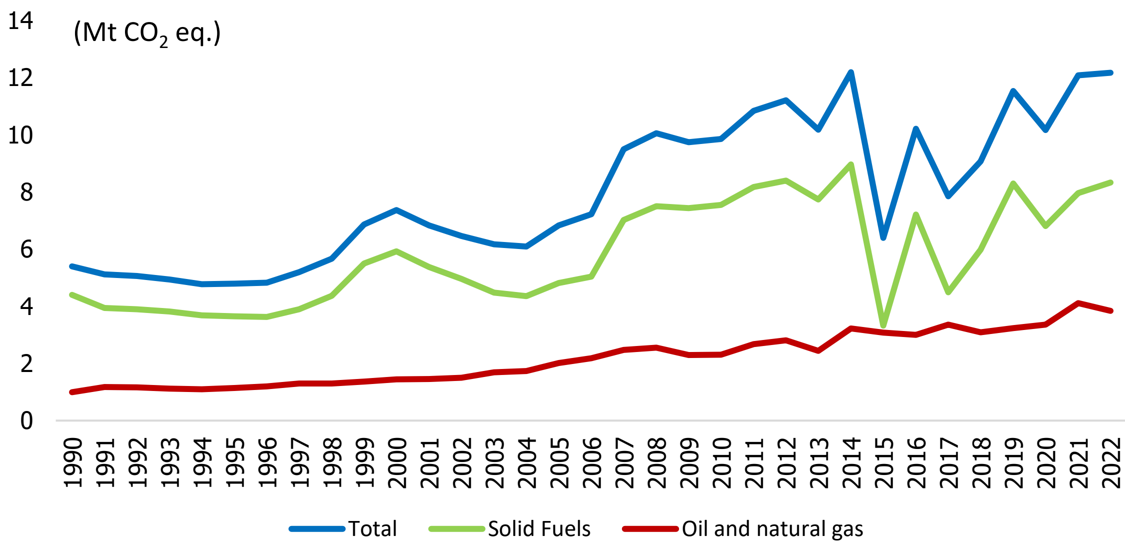
Emissions from transport sector increased 241% (65 Mt CO_2 eq.) in 2022 compared to 1990. In the same period increase in road transportation emissions was 249.4%, in domestic aviation it was 265.2%

and in domestic navigation it was 125.6%. Emissions from railway transport decreased by 29.1% between 1990 and 2022.

Total fugitive emissions for 2022 were 12.2 Mt CO_2 eq., representing 2.2% of total GHG emissions (excluding LULUCF). Oil and natural gas systems contributed 32%, solid fuels account for the remaining 68% of fugitive emissions.

Overall fugitive emissions increased 125.7% between 1990 and 2022. In 2014 a serious mine accident happened and many underground mines were closed in the following year as a precaution, therefore in 2015 fugitive emissions were decreased remarkably. In 2022, the underground coal production activity increased and therefore in 2022 fugitive emissions from solid fuels were increased. In overall, from 1990 to 2022, fugitive emissions from oil and natural gas systems increased by 286.8%. Emissions from solid fuels increased by 89.3% in the same period.

Figure 3.2 Fugitive emissions, 1990-2022



2006 IPCC Guidelines are used for energy sector emission estimation. The methodology for emissions from stationary energy sectors is a mix of T1, T2 and T3 approaches. In transport sector, T1 and T2 approaches have been used. Fugitive emissions were estimated by T1 approach (Table 3.3).

Table 3.3 Summary of methods and emission factors used in energy sector

GHG sources and sink categories	CO_2 Method applied	CO_2 Emission factor	CH_4 Method applied	CH_4 Emission factor	N_2O Method applied	N_2O Emission factor
1. Energy	T1,T2,T3	CS,D,PS	T1,T2,T3	D,PS	T1,T2,T3	D,PS
A. Fuel combustion	T1,T2,T3	CS,D,PS	T1,T2,T3	D,PS	T1,T2,T3	D,PS
1. Energy industries	T2,T3	CS,D,PS	T2,T3	D,PS	T2,T3	D,PS
2. Manufacturing industries and construction	T1,T2	CS,D	T1	D	T1	D
3. Transport	T1,T2	CS,D	T1,T2	D	T1,T2	D
4. Other sectors	T1,T2	CS,D	T1	D	T1	D
B. Fugitive emissions from fuels	T1	D	T1	D	T1	D
1. Solid fuels	NA	NA	T1	D	NA	NA
2. Oil and natural gas	T1	D	T1	D	T1	D
C. CO_2 transport and storage	T1	D	-	-	-	-

Country specific and plant specific carbon contents of liquid, solid and gaseous fuels are used for CO_2 emissions estimation. For CH_4 and N_2O emissions, 2006 IPCC default emissions factors are used.

Sector QA/QC and Verification

Quality control for energy category was performed on the basis of QA/QC plan of Türkiye. All emission factors and implied emission factors are compared with 2006 IPCC Guideline defaults and any outlines were examined. In this inventory, 1A2 and 1A4 sectorial approach emissions and 1AB reference approach fuel combustion emissions were calculated on SAS and it was double checked by the calculations on the Excel sheets by two different experts and any findings were corrected.

The main critic during the reviews is the consistency of the energy sector. This is because the national energy balance tables, which are the main data source of energy sector, are not in time series. Inconstancies come to exist when the national energy balance tables are used in the time series inventory calculations. In order to overcome this problem national energy balance tables should be reallocated and made consistent in the time series. This problem will be handled in the following years.

3.2. Fuel Combustion (Sector 1.A)

The major source of GHGs in Türkiye is the fossil fuel combustion. The emissions from fossil fuel combustion are calculated by TurkStat with cooperation with the Ministry of Energy and National Resources(MENR) and the Ministry of Transport and Infrastructure (MoTI). The emissions from public electricity and heat production were calculated by MENR and the emissions from transport were calculated by MoTI, and the other energy sub-sectors were calculated by TurkStat. 2006 IPCC Guidelines were used in emissions estimation for all energy subcategories.

The emissions from public electricity and heat production (1.A.1.a) are calculated on the basis of plant specific fuel consumption and net calorific values (NCVs) with country specific carbon contents of fuels. Technology specific CH_4 and N_2O emission factors from 2006 IPCC Guidelines are used for 1.A.1.a category for since 2003 and 2006 IPCC Guidelines default CH_4 and N_2O EFs are used for 1990-2002 period since combustion technology data is available from 2003 onward for this category.

For petroleum refining sector (1.A.1.b), fuel consumption data, NCVs and carbon content of fuels are compiled directly from the refineries. In the same way for manufacture of solid fuels (1.A.1.c) categories, plant specific AD and plant specific carbon content are used in the emission estimation. 2006 IPCC Guidelines default EFs are used for CH_4 and N_2O emission estimation.

Emissions from manufacturing industry and construction and other sectors (1.A.2), (1.A.4) were estimated by using energy balance tables. For CO_2 emission estimation both country specific and default carbon contents and oxidation factors are used depending on the data availability. 2006 IPCC Guidelines default EFs are used for CH_4 and N_2O emission estimation.

Transportation sector (1.A.3) consists of road transportation, domestic aviation, railways, domestic navigation and pipeline transportation. Data availability in road transportation, navigation sector and railways allows mostly T1 methodology in the emission estimations. Country specific carbon content of diesel oil and residual fuel oil are used for CO_2 emission estimations but for gasoline and liquefied petroleum gas (LPG) 2006 IPCC default emission factors are used. T2 methodology was used for the calculation of emissions from domestic aviation. Also T2 methodology was used for the calculation of CO_2 emissions from pipeline transportation. 2006 IPCC Guidelines default EFs are used for CH_4 and N_2O emission estimation. The following table summarizes the data source for the 1A sectors.

Table 3.4 Summary table for the data source in fuel combustion (1A) sector

Category	Data Source
1A1a Electricity and Heat Production	Plant specific
1A1b Petroleum Refining	Plant specific
1A1c Manufacturing of Solid Fuels and Other Energy Industries	Plant specific
1A2 Manufacturing Industries and Construction	National energy balance table
1A3 Transport	See chapter 3.2.6
1A4 Other Sectors	National energy balance table
1AB Fuel Combustion Reference Approach	National energy balance table
1AD Feedstocks Reductants and Other non-Energy use of fuels	See chapter 3.2.3

National energy balance tables, which are published by the MENR every year, are the most important input for the energy sector emission calculations. The source of data for the electricity production sector of national energy balance is Turkish Electricity Transmission Corporation (TEİAŞ). The data that TEİAŞ sends includes electricity generation, fuel consumption in both original units and TJ, with respect to energy resources and license type of electricity generators. After the data is compared with previous years, it is directly used in the relevant sections of the energy balance table. For the supply part of national energy balance table (indigenous production, import, export, bunkers, stock change), the administrative sources of relevant stakeholders such as EPDK, BOTAŞ, TEİAŞ, TTK, TKİ, MTA, MAPEG are utilized. For the demand part of national energy balance table, the industry sector data is collected through questionnaires applied by MENR/EİGM to the relevant companies/firms. For the other sectors, administrative sources of relevant stakeholders are used. In the process of compiling data, the sectoral reports of stakeholders are examined, as well as time series analysis and quality control with respect to both energy resources and sectors are applied. The following table shows the country specific carbon content (as ton carbon / TJ fuel) of fuels used in calculating the CO_2 emissions. NCVs can be found Annex 3.

Table 3.5 Country specific carbon contents of fuels

Fuel types	**Unit**	**1990**	**2000**	**2010**	**2015**	**2018**	**2019**	**2020**	**2021**	**2022**
Hard coal	t/TJ	25.79	26.38	27.28	26.16	26.08	26.87	25.56	26.09	25.63
Lignite	t/TJ	32.79	31.61	31.57	30.57	30.51	30.09	29.80	29.60	29.69
Coke	t/TJ	30.14	30.14	29.95	30.10	29.48	29.59	30.19	29.67	30.79
Petrocoke	t/TJ	26.55	26.55	26.55	26.55	26.55	26.55	26.55	26.55	26.55
Fuel oil	t/TJ	21.33	21.33	21.33	21.33	21.33	21.33	21.33	21.33	21.33
Diesel	t/TJ	20.03	20.03	20.03	20.03	20.03	20.03	20.03	20.03	20.03
Naphta	t/TJ	20.13	20.13	20.13	20.13	20.13	20.13	20.13	20.13	20.13
Natural gas	t/TJ	15.13	15.13	15.17	15.19	15.08	14.64	15.19	15.12	15.20

The following table shows the country specific oxidation factors of fuels used in calculating the CO_2 emissions factors.

Table 3.6 Country specific oxidation factor of fuels

Fuel types	1990	2000	2010	2015	2017	2018	2019	2020	2021	2022
Hard coal	0.988	0.988	0.985	0.963	0.975	0.975	0.983	0.979	0.979	0.976
Lignite	0.950	0.950	0.953	0.960	0.973	0.973	0.966	0.959	0.967	0.963
Fuel oil	0.984	0.984	0.984	0.984	0.984	0.984	0.984	0.984	0.984	0.984
Diesel	0.984	0.984	0.984	0.984	0.984	0.984	0.984	0.984	0.984	0.984

The following table shows the CO_2 emissions factors of all the fuels. The decrease in carbon content over time (32.79 and 29.60 t/TJ for 1990 and 2022,) led to a lower EF even when the oxidation factor increases.

Either country specific carbon contents or IPCC default carbon contents are used in the calculations depending on the data availability. CO_2 EFs are calculated by the formula below.

CO_2 EF = C content of fuel x Oxidation factor of fuel x (44/12)

Country specific carbon content and oxidation rates were calculated through fuel analysis and ash-slag or stack gas analysis reports.

Table 3.7 CO_2 emission factors of fuels

Fuel types	Unit	1990	2000	2010	2017	2018	2019	2020	2021	2022
Hard coal	t/TJ	93.4	95.5	98.6	94.5	94.1	96.9	91.8	93.64	91.71
Lignite	t/TJ	114.2	110.1	110.3	107.2	107.5	106.6	104.8	104.08	104.79
Asphaltite	t/TJ	96.1	96.1	96.1	96.1	96.1	96.1	96.1	96.1	96.1
Coke	t/TJ	110.5	110.5	109.8	112.2	108.1	108.5	110.7	108.8	112.90
Coal tar	t/TJ	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7
Crude oil	t/TJ	73.3	73.3	73.3	73.3	73.3	73.7	73.7	73.7	73.7
Petrocoke	t/TJ	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4
Fuel oil	t/TJ	77.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0
Diesel	t/TJ	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3
Gasoline	t/TJ	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3
LPG	t/TJ	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1
Rafinery gas	t/TJ	57.6	57.6	57.6	57.6	57.6	57.6	57.6	57.6	57.6
Aviation fuel	t/TJ	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5
Kerosene	t/TJ	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9
Naphta	t/TJ	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7
Intermediate products	t/TJ	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
Base oils	t/TJ	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
White spirit	t/TJ	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
Bitumen	t/TJ	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7
Other petroleum products	t/TJ	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
Natural gas	t/TJ	55.5	55.5	55.6	55.6	55.6	53.7	53.7	55.4	55.4
Fuel wood	t/TJ	111.8	111.8	111.8	111.8	111.8	111.8	111.8	111.8	111.8
Animal&Vegetable waste	t/TJ	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1
Biofuels	t/TJ	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8

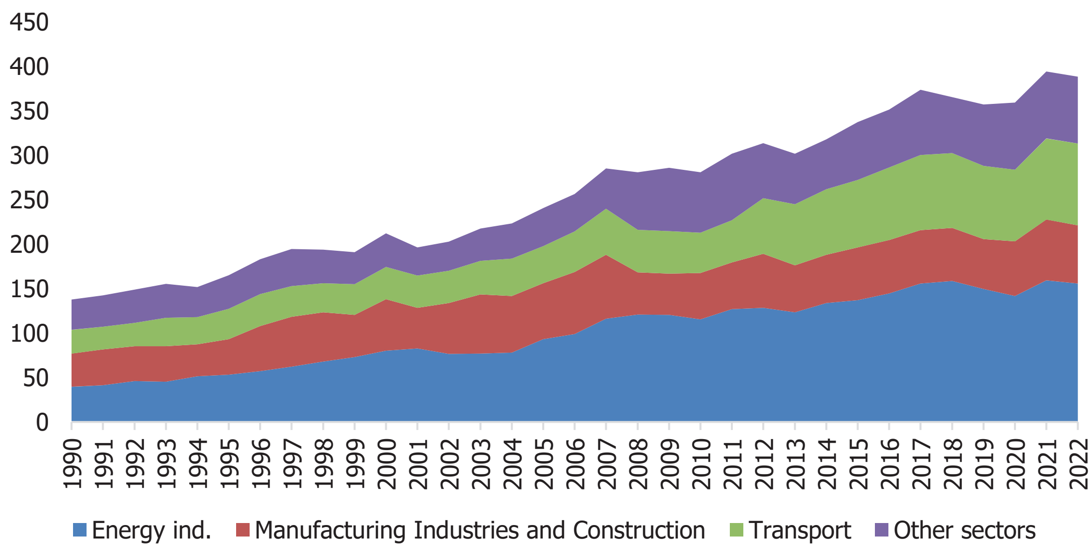
CO_2, CH_4 and N_2O Emissions from fuel combustion were calculated for the period 1990-2022

Table 3.8 Emissions from fuel combustion (1A), 1990-2022

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	132 122	139	6.5	137 752
1995	159 369	134	7.8	165 187
2000	206 740	122	8.5	212 388
2005	234 899	113	10.5	240 836
2010	272 854	168	13.2	281 078
2011	293 894	148	14.1	301 777
2012	306 765	156	9.8	313 728
2013	295 446	131	9.9	301 746
2014	311 674	131	10.6	318 154
2015	332 096	80	12.2	337 584
2016	345 902	82	13.0	351 652
2017	367 689	94	13.8	373 976
2018	359 999	83	12.5	365 655
2019	351 707	90	12.0	357 400
2020	353 274	100	12.4	359 344
2021	387 740	95	15.0	394 390
2022	382 150	86	14.5	388 408

Figure 3.3 CO_2 emissions from fuel combustion, 1990-2022



Energy industry has the highest share in total CO_2 emission from fuel combustion in 2022. It is followed by transport, other sectors, and manufacturing industries and construction.

Figure 3.4 CO_2 emissions from fuel combustion by sectors, 1990 and 2022

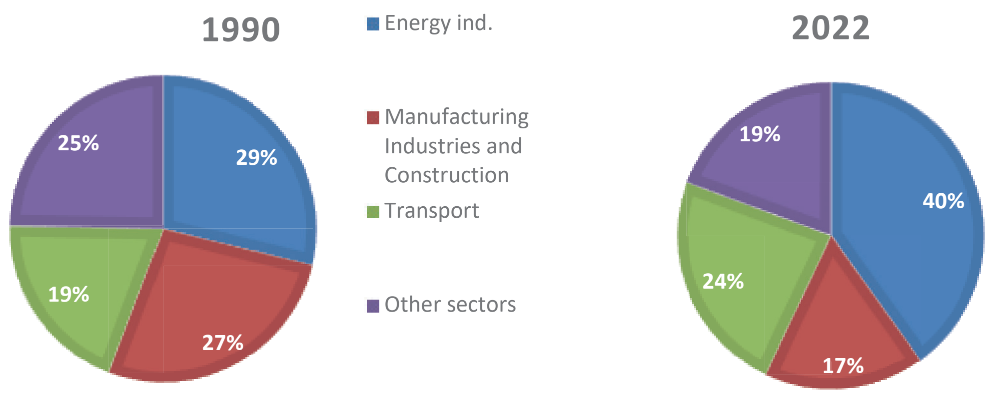


Figure 3.5 CH_4 emissions from fuel combustion, 1990-2022

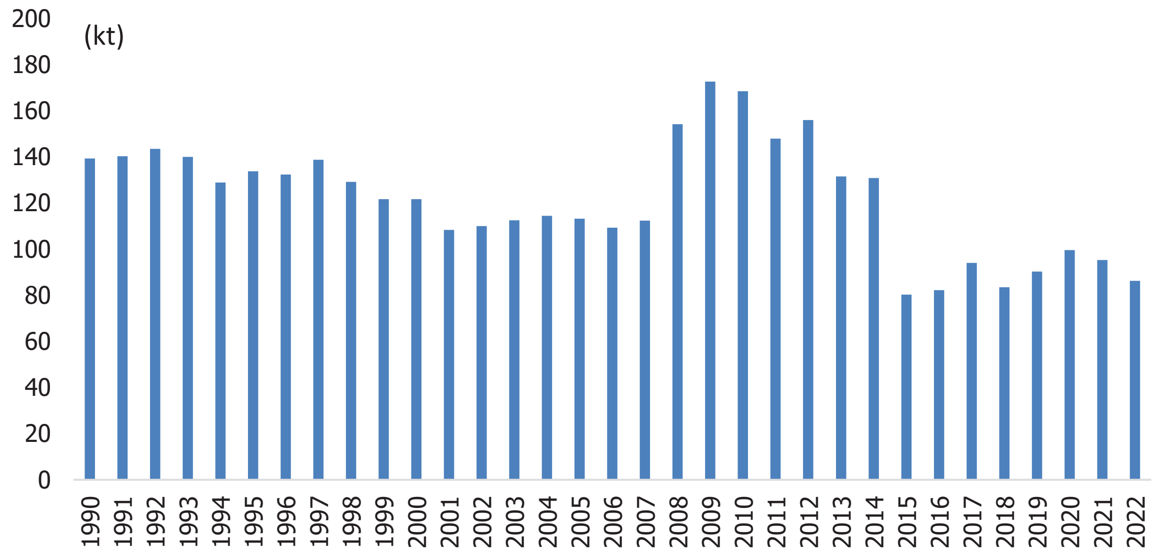
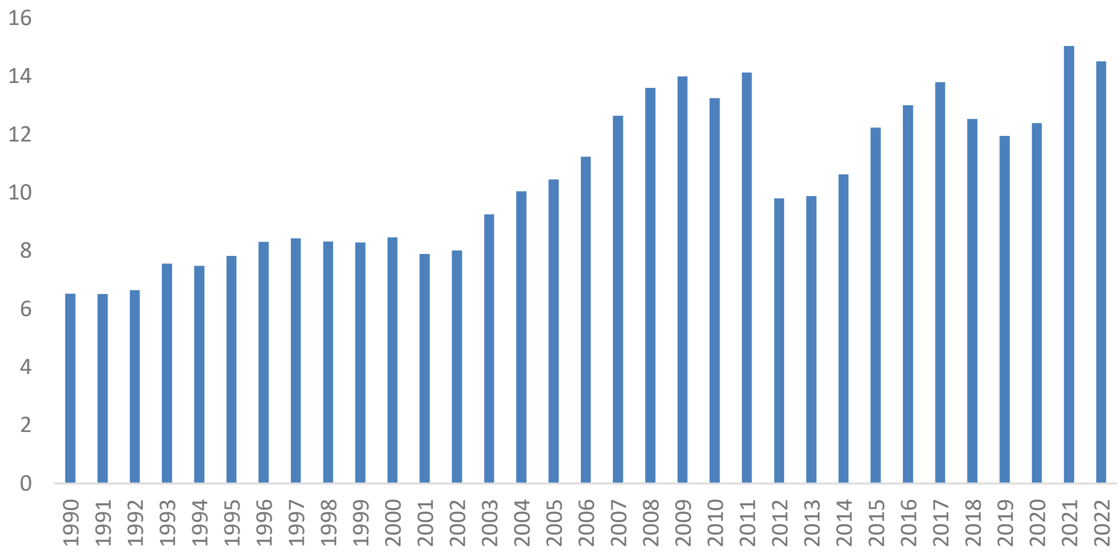


Figure 3.6 N_2O emissions from fuel combustion, 1990-2022



3.2.1. Comparison of the sectoral approach with reference approach

The IPCC Reference Approach is a top down inventory based on production, imports, exports, stock change and international bunker consumption of fuels.

2006 IPCC methodology is used for reference approach CO_2 estimation. The estimation based on the apparent consumption of fuels in the country. The apparent consumption of primary fuels has been calculated by using the following formula:

Apparent consumption = Domestic production + imports - exports - change (increase/decrease) in stocks - international bunkers

Apparent consumption of secondary fuels has been calculated by using the following formula:

Apparent consumption= imports - exports - change (increase/decrease) in stocks- international bunkers

The apparent consumption is need to be adjusted for feedstocks, reductants and other non-energy use of fuels. The fossil fuels used for non-energy purposes should be deducted from the apparent consumption in order to avoid double counting in reference approach. (See section 3.2.3 *Feedstocks, Reductants and Other Non-Energy Use of Fuels*)

Domestic production, import, export, stock change and international bunkers have been taken from national energy balance tables for all primary fuels and petroleum products in ktoe unit.

Note that the reference approach emission calculation is dependent on the national energy balance tables and the fuel classification in the national energy balance table is different than CRT fuel classification. Therefore, the fuels in the national energy balance table is allocated into CRT fuel classification according to the table below.

The allocation of fuels into the CRT 1AB category is shown in the table below.

Table 3.9 Fuel allocation in reference approach

Fuel allocated under national energy balance table	Fuel allocated under CRT 1AB sector
Hard coal	Coking coal
Lignite	Lignite
Asphaltite	Sub bitiminous coal
Coke	Coke oven coke
Coal tar	Coal tar
Crude oil	Crude oil
Petrocoke	Petroleum coke
Fuel oil	Residual fuel oil
Diesel	Diesel oil
Gasoline	Gasoline
LPG	LPG
Rafinery gas	Other oil
Aviation fuel	Jet kerosene
Kerosene	Other kerosene
Naphta	Naphta
Intermediate products	Other oil
Base oils	Other oil
White spirit	Other oil
Bitumen	Other oil
Other petroleum products	Other oil
Natural gas	Natural gas
Fuel wood	Solid biomass
Animal&Vegetable waste	Solid biomass
Biofuels	Liquid biomass

Table 3.10 CO_2 emissions from fuel combustion, 1990-2022

(kt)

	Reference Approach				Sectoral Approach				
Year	Liquid fuels (excluding international bunkers)	Solid fuels (excluding international bunkers)	Gaseous fuels	Total	Liquid fuels (excluding international bunkers)	Solid fuels (excluding international bunkers)	Gaseous fuels	Other fossil fuels	Total
1990	66 028	63 511	5 538	135 077	60 896	63 256	7 971	NO	132 122
1995	83 270	68 610	12 363	164 243	78 818	65 410	15 141	1	159 369
2000	91 665	94 125	28 572	214 362	83 026	92 899	30 772	42	206 740
2005	94 669	89 275	50 823	234 767	84 653	95 362	54 808	75	234 899
2010	86 191	126 348	72 623	285 163	80 345	120 799	71 269	441	272 854
2011	85 800	130 463	85 643	301 906	83 388	125 332	84 629	545	293 894
2012	93 011	135 973	84 926	313 910	89 161	131 209	85 592	803	306 765
2013	95 466	118 580	86 085	300 131	93 763	114 808	85 708	1 166	295 446
2014	98 421	128 608	92 030	319 059	98 378	119 819	92 239	1 238	311 674
2015	109 303	131 236	90 528	331 067	106 910	128 158	95 216	1 812	332 096
2016	115 535	139 291	87 954	342 780	114 649	140 046	89 699	1 508	345 902
2017	116 392	152 470	101 863	370 724	117 257	146 143	102 454	1 836	367 689
2018	111 827	157 027	93 420	370 803	113 695	150 806	93 286	2 211	359 999
2019	109 765	167 917	82 157	368 610	111 017	154 615	82 152	3 924	351 707
2020	113 054	158 904	91 445	373 016	111 676	148 327	89 923	3 348	353 274
2021	117 358	159 346	111 890	400 723	117 610	153 299	112 662	4 169	387 740
2022	123 008	129 348	99 638	365 549	123 544	155 981	97 990	4 636	382 150

Figure 3.7 CO_2 emissions from fuel combustion, 1990-2022

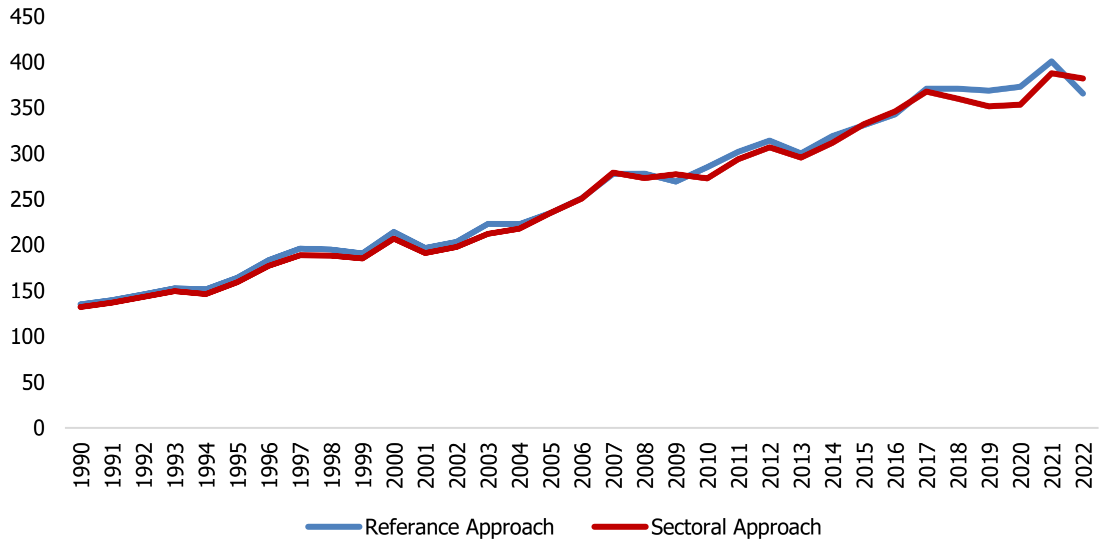


Table 3.11 Comparison of CO_2 from fuel combustion between reference and sectoral approach, 1990-2022

	Reference approach		Sectoral approach		Difference in emissions (%)
Year	Apparent consumption (PJ)	Emissions (kton CO_2)	Apparent consumption (PJ)	Emissions (kton CO_2)	
1990	1 795	135 077	1 533	132 122	2.2
1995	2 188	164 243	1 924	159 369	3.1
2000	2 891	214 362	2 547	206 740	3.7
2005	3 293	234 767	3 019	234 899	-0.1
2010	4 004	285 163	3 487	272 854	4.5
2011	4 300	301 906	3 824	293 894	2.7
2012	4 460	313 910	3 987	306 765	2.3
2013	4 343	300 131	3 883	295 446	1.6
2014	4 594	319 059	4 149	311 674	2.4
2015	4 826	331 067	4 413	332 096	-0.3
2016	5 042	342 780	4 585	345 902	-0.9
2017	5 372	370 724	4 892	367 689	0.8
2018	5 270	370 803	4 742	359 999	3.0
2019	5 163	368 610	4 574	351 707	4.8
2020	5 314	373 016	4 669	353 274	5.6
2021	5 798	400 723	5 215	387 740	3.3
2022	5 314	365 549	5 032	382 150	-4.3

Explanation of differences:

While converting to common energy units, the reference approach multiplies the apparent fuel consumption by a single conversion factor. On the other hand, each fuel has different heat content. Sectoral approach uses sector specific heat value provided in the energy balance tables.

In sectoral approach fuel consumption and NCVs of 1A1 category have been collected directly from the end users (from electricity and heat producers, refineries and coke producers). It brings differences between the sectoral and reference approaches since the plant level NCVs differ from average NCVs used in energy balance tables. Especially for solid fuels and more specifically for the Turkish lignite, such differences in NCVs are causing differences. Since the Turkish lignite is poor quality fuel, its NCV is generally too low from that of literature lignite. In plant level, data regarding the NCV of lignite changes in a wide range (from 1000 to 6000 kg/kcal). However, in national balance tables, an average NCV value is about 2200 kcal/kg is used. Based on the quality of lignite used in a specific year, consumption in TJ differs from the national energy balance data. This causes differences in emissions.

Recalculation:

There is recalculation in this sector due to the change of AD, methodology or minor correction and varies between -6.7% and 0.04%.

3.2.2. International bunker fuels

In consistent with the UNFCCC reporting guidelines, CO_2, CH_4 and N_2O emissions from international bunker fuels are calculated and reported separately.

3.2.2.1. International aviation

The fuel type used in international aviation is jet kerosene. Table 3.12 shows the trend in emissions of CO_2, CH_4, and N_2O from international aviation between 1990 and 2022.

GHG emissions from international aviation have an increasing trend in consistent with the growth in international aviation sector. CO_2 eq. emissions were 12.47 Mt in 2022 (Figure 3.8) while it was 0.56 Mt in 1990.

Emissions from international aviation are calculated using the T1 methodology given in the 2006 IPCC Guidelines. The following equation is used.

$$Emissions = fuel\ consumption * EF$$

According to the 2006 IPCC Guidelines, the Tier 1 method should only be used for aircraft using aviation gasoline, not larger aircraft using jet kerosene however use of a higher tier method is not possible in Türkiye because aircraft operational use data are not available.

Energy balance tables were used for AD. To estimate emissions, Türkiye applies the default emission factors from the 2006 IPCC Guidelines as follows: CO_2 (71500 kg/TJ), CH_4 (0.5 kg/TJ) and N_2O (2 kg/TJ).

Figure 3.8 GHG emissions from international aviation, 1990-2022

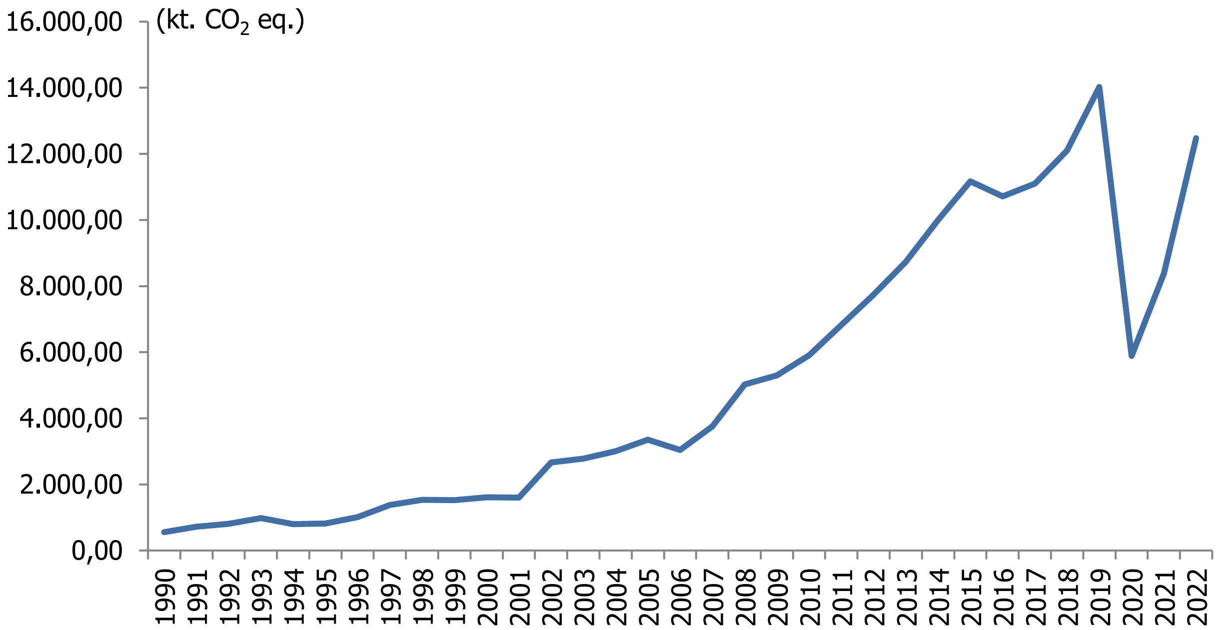


Table 3.12 Emissions and fuel for international aviation, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq (kt)	Aviation bunkers (TJ)
1990	552	0.004	0.02	556	7 718
1995	807	0.006	0.02	813	11 290
2000	1 599	0.011	0.04	1 611	22 359
2005	3 330	0.023	0.09	3 355	46 570
2010	5 858	0.041	0.16	5 903	81 937
2011	6 769	0.047	0.19	6 821	94 671
2012	7 684	0.054	0.21	7 743	107 473
2013	8 661	0.061	0.24	8 727	121 129
2014	9 922	0.069	0.28	9 998	138 775
2015	11 085	0.078	0.31	11 170	155 037
2016	10 630	0.074	0.30	10 710	148 668
2017	11 015	0.077	0.31	11 097	154 053
2018	12 006	0.084	0.34	12 096	167 911
2019	13 917	0.097	0.39	14 023	194 649
2020	5 842	0.041	0.16	5 887	81 712
2021	8 321	0.058	0.23	8 384	116 377
2022	12 376	0.087	0.35	12 470	173 091

3.2.2.2. International navigation

The fuel type used in international navigation is diesel and residual fuel oil. Table 3.13 shows the trend in emissions of CO_2, CH_4 and N_2O from international navigation between 1990 and 2022.

GHG emissions from international navigation have an increasing trend corresponding to the growth in the international navigation sector. CO_2 eq. emissions were 2.07 Mt in 2022 (Figure 3.9) while it was 0.4 Mt in 1990.

Emissions from international navigation were calculated using the T1 and T2 methodology given in 2006 IPCC Guidelines. Country specific carbon content is used for CO_2 emission estimation. 2006 IPCC default EFs are used for CH_4 and N_2O emissions. The following equation is used. Activity data in international navigation provided by the EMRA were compared with those of DG of Mining and Petroleum Affairs, reported to IEA.

$$Emissions = \sum Fuel\ consumed_{ab} * EF_{ab}$$

Where:

a = fuel type (residual fuel oil and gas diesel oil)

b = water-borne navigation type (the type of vessel b is ignored at Tier 1)

Country specific carbon content is used for CO_2 emission estimation. To estimate CH_4 and N_2O emissions, Türkiye applies the default emission factors from the 2006 IPCC Guidelines as follows: CH_4 (7 kg/TJ) and N_2O (2 kg/TJ).

Figure 3.9 GHG emissions from international navigation, 1990-2022

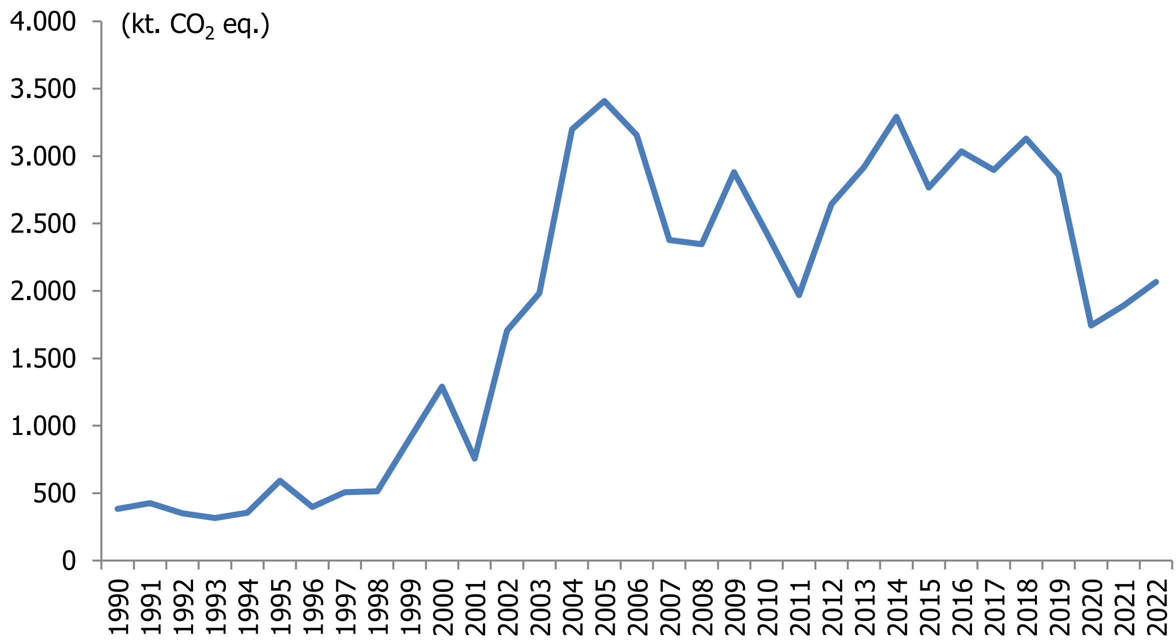


Table 3.13 Emissions and fuel for international navigation, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Navigation bunkers (TJ)
1990	379	0.035	0.01	383	5 035
1995	587	0.055	0.02	593	7 819
2000	1 279	0.118	0.03	1 291	16 861
2005	3 376	0.312	0.09	3 409	44 586
2010	2 407	0.217	0.06	2 430	31 058
2011	1 951	0.176	0.05	1 970	25 160
2012	2 618	0.237	0.07	2 643	33 786
2013	2 892	0.261	0.07	2 919	37 316
2014	3 260	0.294	0.08	3 291	41 958
2015	2 742	0.248	0.07	2 768	35 358
2016	3 006	0.271	0.08	3 034	38 654
2017	2 871	0.262	0.08	2 898	37 487
2018	3 101	0.284	0.08	3 130	40 520
2019	2 833	0.260	0.07	2 860	37 186
2020	1 726	0.162	0.05	1 743	23 145
2021	1 872	0.176	0.05	1 890	25 120
2022	2 047	0.194	0.06	2 067	27 701

Recalculations:

There is no recalculation for this category.

3.2.3. Feedstocks, Reductants and other non-energy use of fuels

In accordance with the 2006 IPCC Guidelines, AD and emissions associated with the non-energy use of fuels are not reported within the fuel combustion subsector. The table below summarizes reporting of carbon stored and emissions related to use of feedstock, reductants and other non-energy use of fuels.

Table 3.14 Summary table for use of feedstock, reductants and other non energy use of

Use of fuel	Reported in inventory	Data Source
Reductant for ferroalloy production	Emissions in 2.C.2; in RA subtracted from coke	Plant specific
Reductant for carbide production	Emissions is 2.B.5; in RA subtracted from coke	Plant specific
Reductants for steel production in Electric Arc Furnaces	Emissions in 2.C.1; in RA subtracted from coke oven coke and natural gas	Estimated from EAF primary steel production data
Reductants for steel production in integrated iron and steel plants	Emissions is 2.C.1; in RA subtracted from coking coal	Plant specific
Feedstock for ammonia production	Emissions in 2.B.2; in RA subtracted from natural gas	Plant specific
Feedstock for petrochemical industry	Carbon stored, in RA subtracted from naphta	National energy balance table
Use of lubricants	Emissions in2.D.1; in RA subtracted from other oil	National energy balance table (Aggregated under other oil)
Use of parrafin and wax	Emissions in 2.D.1; in RA subtracted from other oil	National energy balance table (Aggregated under other oil)
Use of bitumen for road paving, asphalt roofing etc.	Carbon stored, in RA subtracted from other oil	National energy balance table (Aggregated under other oil)
Refinery feedstocks	Carbon stored, in RA subtracted from other oil	National energy balance table (Aggregated under other oil)

Fossil fuels are used in integrated iron and steel plants for reducing iron ore into iron metal. The reduction process causes CO_2 emissions. These emissions are reported under IPPU category. The amount of carbon (fossil fuel originated, not limestone etc.) reported in the IPPU is converted into the amount of coking coal and it is subtracted from the reference approach.

In the national energy balance tables, feedstock and non-energy use of fuels are given separately and those consumptions are not included in fuel consumptions. Naphtha is given as feedstock in the national energy balance tables. Fuels used for non-energy purposes are lubricants, bitumen, solvents and rafinery feedstocks. But they were not given separately in the national energy balance tables till 2015. They were included in the aggregated item "other petroleum products".

Emissions from lubricants and paraffin-wax use are included under 2.D-non-energy products from fuels and solvent use category. However, bitumen is used for road paving or asphalt roofing purposes and carbon is stored in the products it is not released. Refinery feedstock is used in the refining industry and is transformed into one or more components and/or finished products. Naphtha is used as feedstock for petrochemical industry.

Recalculation:

There is no recalculation in this sector.

3.2.4. Energy industries (Category 1.A.1)

Source Category Description:

This source category includes the emission from the public electricity and heat production, petroleum refining and manufacture of solid fuels in Türkiye. This category is one of the main emission sources in Türkiye. The share of GHG emissions as CO_2 eq. from energy industries in total fuel combustion was 40.1% in 2022 while it was 28.8% in 1990. The source category 1.A.1 is a key category in terms of emission level and emission trend of CO_2 from liquid, solid and gaseous fuels in 2022.

Table 3.15 GHG emissions from energy industries, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)
1990	39 591	0.4	0.4	39 701	436 388
1995	53 049	0.6	0.5	53 199	591 111
2000	79 900	0.9	0.7	80 116	947 808
2005	92 297	1.2	2.5	93 006	1 147 858
2010	114 282	1.7	4.0	115 387	1 431 722
2011	125 868	1.9	4.2	127 040	1 570 710
2012	127 230	1.9	3.8	128 300	1 611 017
2013	122 197	1.8	4.1	123 322	1 548 934
2014	132 689	1.9	4.4	133 897	1 716 886
2015	135 908	1.9	3.9	136 984	1 713 903
2016	143 442	2.0	4.1	144 592	1 768 374
2017	154 395	2.0	4.6	155 663	1 928 822
2018	157 684	2.0	3.3	158 626	1 901 992
2019	148 820	1.8	2.7	149 585	1 709 837
2020	141 049	1.8	2.9	141 859	1 726 497
2021	158 004	2.3	4.8	159 351	2 034 495
2022	154 750	2.1	4.3	155 937	1 888 390

Methodological Issues:

2006 IPCC Guidelines T2 and T3 approaches were used for emission calculation in energy industries. The emissions from public electricity and heat production (1.A.1.a) are calculated on the basis of plant specific fuel consumption and NCVs with country specific carbon contents of fuels. For petroleum refining sector, fuel data, NCV and carbon content of fuels were compiled directly from the refineries. For manufacture of solid fuels (1.A.1.c) category, plant specific AD and carbon content were used in the emission estimation.

Emissions from CRT category 1.A.1.a, have been estimated by the MENR by using 2006 IPCC T2, T3 approaches. Plant-specific NCVs were used to calculate heat values that led to emissions. Plant level fuel consumption and NCVs of fuels are received from Turkish Electricity Transmission Company (TEİAŞ-authority for Turkish electricity transmission). Carbon contents of fuels are calculated using fuel analysis reports and oxidation rates are calculated using ash and slag analysis reports for solid fuels, and stack gas analysis reports for liquid and gaseous fuels. CO_2 emissions from liquid, solid and gaseous fuels used in public electricity and heat production (1.A.1.a) are calculated using country specific carbon content of fuels and oxidation rates. For biomass and other fossil fuels on the other hand, default carbon contents and oxidation rates were used given in the 2006 IPCC Guidelines. Activity data of CH_4 and N_2O emissions from CRT category 1A1a, have been estimated by using plant specific fuel consumption and NCVs. For the years 2000-2020 technology information of power plants were obtained. According to type of technology, using 2006 IPCC Guidelines for National Greenhouse Gas Inventories, emission factors were chosen in order for CH_4 and N_2O to be estimated with Tier 3.

Emissions from petroleum refining (CRT 1.A.1.b) were calculated according to 2006 IPCC T2 approach by TurkStat. Fuel consumption, NCVs and carbon content of fuels were compiled directly from refineries. CO_2 emissions from 1.A.1.b were calculated by using average carbon contents of fuels used in the refineries with IPCC default oxidation rates. CH_4 and N_2O emissions from CRT category 1.A.1.b, have been estimated by using refineries total fuel consumption and average NCVs for refineries with IPCC default EFs.

Emissions from manufacture of solid fuels (CRT 1.A.1.c) were calculated according to 2006 IPCC T2, T3 approaches by TurkStat. Coke production in integrated iron and steel production plants have been considered in this category. Plant specific fuel consumption, NCVs and carbon content of fuels were compiled from each plant. CO_2 emissions from 1.A.1.c were calculated by using plant specific AD, carbon contents of fuels and IPCC default oxidation rates. CH_4 and N_2O emissions from CRT category 1.A.1.c, have been estimated by using plant specific fuel consumption and NCVs and IPCC default EFs.

Recalculation:

There is recalculation in emissions from 1.A.1.b. Petroleum Refining due to the use of MRV data for the years 2018-2022 and emissions from 1.A.1.c for the years 1990-2017 due to the estimation of historical data based on the amount of petroleum refined.

3.2.4.1. Public electricity and heat production (Category 1.A.1.a)

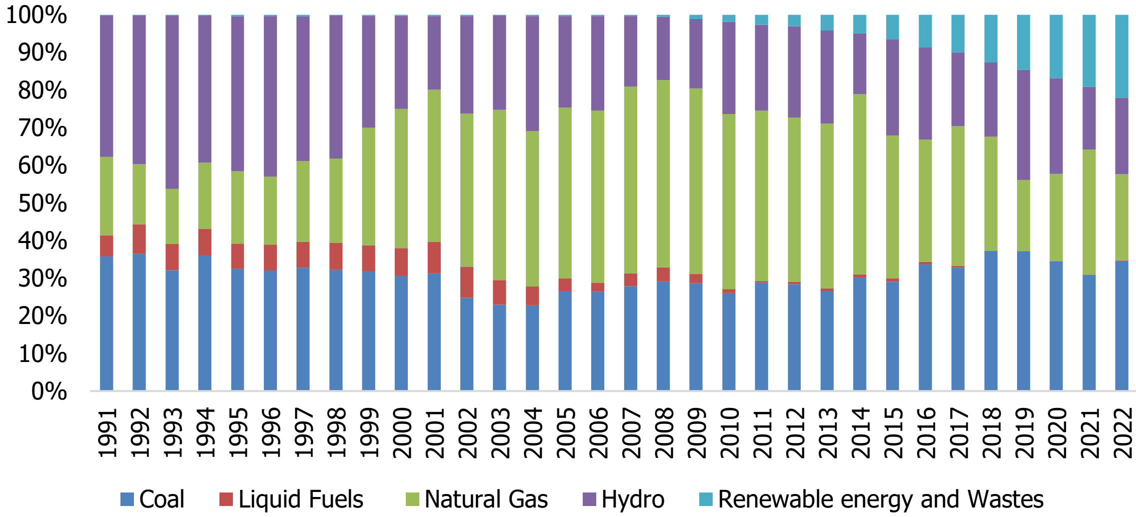
Source Category Description:

Public electricity and heat production category includes electricity and heat production of all electricity generation installations in operation, including auto producers. Auto producers are the facilities that produce electricity that they use for their purposes. Their AD (Activity Data) for electricity production and sold heat are taken under 1.A.1.a. Unsold heat, namely the heat they use for industry purpose, on the other hand, is taken under the related industry subcategory they belong to avoid double-counting for the whole time series. For 1.A.1.a sector, plant-specific AD's are gathered from Turkish Electricity Transmission Company (TEİAŞ).

Total installed capacity reached 103,809 MW in 2022 with a 4% increase from the previous year and nearly 6.4 times higher than the 1990 values. The total gross electricity consumption decreased by 0.5% in 2022 compared to the previous year. In 2022, gross consumption was 331,105 GWh; meanwhile, in 2021, this figure was realized as 332,871 GWh. Above mentioned installed capacities, and consumption amounts belong to electricity production companies and auto producers as well. In 2022, natural gas had a high share of 22.9% in all electricity production, which was followed by hydro (20.3%), other bituminous coal (20.4%), Turkish lignite (13.7%), other renewable and wastes (22%) and oil (0.12%), sub bituminous coal (0.5%). From 2021 to 2022, electricity production from hydropower plants increased by 19.4%. The amount of electricity produced from other bituminous coal has increased from 58.03 TWh to 67.01 TWh. On the other hand, electricity production from natural gas decreased from 111.18 TWh to 75.06 TWh and Turkish lignite increased from 42.98 TWh to 45.14 TWh.

In 2022 electricity production from fossil-fueled thermal power plants has accounted for 189.171 TWh of 328.379 TWh production, while in 2021 electricity production from fossil-fueled thermal power plants has accounted for 214.844 TWh of 334.723 TWh production. Fossil fueled thermal share in electricity production decreased from 64.19% in 2021 to 57.61% in 2022.

Figure 3.10 Energy mix of category 1.A.1.a, 1990-2022[1]



There was an increase in wind installed capacity from 10 607 MW in 2021 to 11 396 MW in 2022. Renewable Law, which came into force in 2005 later revised in 2011, provided some supporting mechanisms for purchasing electricity from solar, biomass, geothermal, wind, and hydraulic energy. In the year 2022, solar power plants installed capacity raised to 9 425 MW. The voluntary carbon market's role is important to mention, as many wind projects in the country generate and sell the voluntary carbon credits.

Electricity generation from animal and yard waste has increased by 22% compared to the previous year, reaching 2 309 MW of installed power, generating 9 454 GWh of power in 2022.

In 2022, Total Primary Energy Supply (TPES) of Türkiye was 6 605 510.53 TJ, 1 % decrease compared to 2021. Oil had a share of 1 888 793.09 TJ while hard coal and natural gas accounted for 966 450.93 TJ and 1 813 039.30 TJ, respectively.

[1]Electricity Statistics, TEİAŞ (https://www.teias.gov.tr/tr-TR/turkiye-elektrik-uretim-iletim-istatistikleri)

Figure 3.11 Electricity generation and shares by energy resources, 2021 - 2022[2]

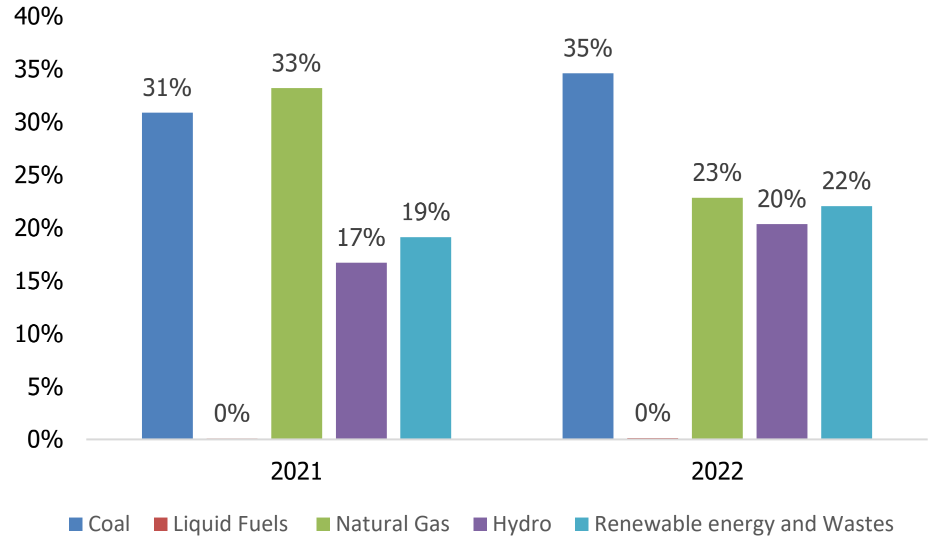
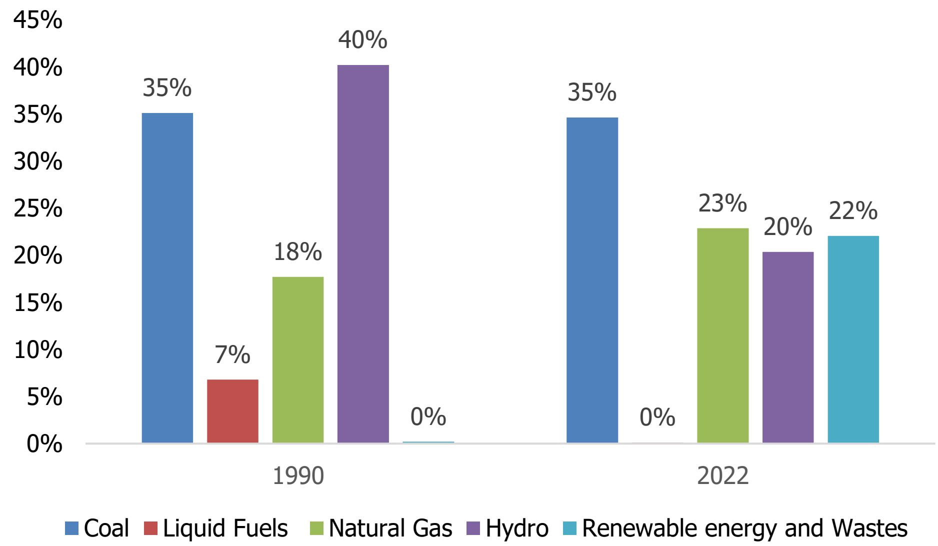


Figure 3.12 Electricity generation and shares by energy resources, 1990 - 2022[3]



Primary energy (domestic) production was 2 128 147.73 TJ in 2022 and provided 32.2% of the overall energy supply. The share of imports in TPES was about 67.8% in 2022.

The production of solid fossil fuels, excluding animal & yard waste, has increased from 747 729.36 TJ in 2021 to 822 001.77 TJ in 2022. The main domestic energy source remains as Turkish lignite, with

[2]Electricity Statistics, TEİAŞ (https://www.teias.gov.tr/tr-TR/turkiye-elektrik-uretim-iletim-istatistikleri)
[3]Electricity Statistics, TEİAŞ (https://www.teias.gov.tr/tr-TR/turkiye-elektrik-uretim-iletim-istatistikleri)

production increased from 83.56 Mt in 2021 to 92.30 Mt in 2022, which represented an increase by about %10.46

GHG emissions from public electricity and heat production in total fuel combustion were 37.9% in 2022, and even it was 24.4% in 1990. According to Table 3.16, fuel consumption decreased from 1 892 330 TJ in 2021 to 1 737 661 TJ in 2022 when the CO_2 emissions decreased from 147 901 kt in 2021 to 143 848 kt in 2022. In other words, fuel consumption decreased by 8.2% compared to the previous year, while CO_2 emissions decreased by 2.7%. The main reason why the decrease in fuel consumption is higher than the decrease in emissions is that the share of coal in electricity generation increased from 30.9% to 34.6%, while the share of natural gas decreased from 33.2 to 22.9 compared to the previous year. Compared to last year, the share of hydroelectricity increased by about 4%, while the share of other renewables in production increased from about 19% to 22%.

Table 3.16 Emissions from category 1A1a, 1990-2022

Year	CO_2	CH_4	N_2O	CO_2 eq.	Fuel
1990	32 823	0.3	0.4	32 927	346 707
1995	45 860	0.5	0.5	46 005	490 230
2000	73 139	0.9	0.7	73 351	854 300
2005	84 623	1.1	2.5	85 326	1 036 864
2010	107 664	1.6	4.0	108 765	1 344 379
2011	118 730	1.8	4.2	119 897	1 478 115
2012	119 702	1.8	3.8	120 768	1 512 807
2013	114 861	1.7	4.0	115 982	1 451 358
2014	125 665	1.8	4.3	126 868	1 624 731
2015	126 767	1.8	3.8	127 836	1 591 475
2016	134 280	1.9	4.1	135 423	1 644 763
2017	144 814	1.9	4.6	146 076	1 804 038
2018	148 992	1.9	3.3	149 928	1 791 670
2019	138 273	1.7	2.7	139 032	1 580 085
2020	130 770	1.7	2.9	131 574	1 585 675
2021	147 901	2.2	4.8	149 243	1 892 330
2022	143 848	1.9	4.2	145 027	1 737 661

Methodological Issues:

Activity Data

The plant-specific activity data for the whole time series is obtained from Turkish Electricity Transmission Company (TEİAŞ) in a compiled form. After data obtaining, sector experts checked whether there were data errors or omissions, and then data compared with fuel specific default values from IPCC guidelines and literature. Cross checks, including fuel capacity factor controls, and examining outliers give some opinion about data consistency. Suspicious data are corrected by getting in contact with Turkish Electricity Transmission Company (TEİAŞ).

As soon as the sector experts are assured about data reliability, data entry to the overall calculation table begins. After entering data of every single plant that produced electricity in the related year, the heat content of fuels is calculated with plant-specific data obtained from Turkish Electricity Transmission Company (TEİAŞ). In order to obtain plant-specific activity data, the amount of feedstock fuel used is multiplied by plant-specific NCVs to get heat values in terms of TJ. Average NCVs are given in Table 3.17.

Table 3.17 Average NCVs of fuels used in category 1.A.1.a

		(TJ/kt)
Fuel Type	**Weighted average**	**Default**
Sub-Bituminous Coal	13.38	18.90
Natural gas	48.75	48.00
Residual Fuel Oil	43.32	40.40
Other bituminous coal	23.93	25.80
Turkish lignite	6.53	11.90
Gas\Diesel Oil	43.07	43.00

The multipliers of EF, namely, carbon content and oxidation rates, were calculated. For Turkish lignite, sub-bituminous, and other bituminous coal, ultimate analysis results obtained from coal-fired power plants were used to calculate the related coal types' carbon content. The same procedure was applied for liquid fuels through residual fuel oil characteristics and mass percentage of carbon. For natural gas, volumetric fractions of gas concentrations were obtained through gas chromatography analysis from Petroleum Pipeline Company (BOTAŞ). Using the gases and some stoichiometry density, each gas compound's carbon mass amount was calculated and summed up to reach an overall carbon amount. The oxidation rate of solid fuels was calculated using the mass percentage of carbon in ash-slag analysis reports obtained from coal-firing plants. For gaseous fuels, measured CO concentrations in the stack gas were used in order to calculate the mass percentage of the unoxidized carbon and then the oxidation rate of the related fuel. In order to calculate the oxidation rate of gaseous fuels (natural gas), CO concentrations measured in the stack gas of the related plants were obtained from the Ministry of Environment and Urbanization. Some of the analysis reports and calculation steps were shared in Annex 3. CO_2 EFs used for source category 1.A.1.a were listed in Table 3.18 for the whole time series on a fuel basis.

For CH_4 and N_2O emissions starting from the year 2000, plant-specific technology classification information was obtained from Turkish Electricity Transmission Company (TEİAŞ). Using *Table 2.6: Utility Source Emission Factors* from Stationary Combustion Chapter of Guideline, Tier 3 EFs for CH_4 and N_2O were chosen.

EFs for CH_4 and N_2O were listed in Table 3.19 for the whole time series on a fuel basis.

Table 3.18 CO_2 emission factors used for source category 1.A.1.a, 1990-2022

(t/TJ)

Year	Turkish Lignite	Sub-Bituminous Coal	Other Bituminous Coal	Natural Gas	Residual Fuel Oil	Diesel Oil	LPG	Biogas	Industrial Waste	Wood-wood waste	Coke Oven Gas	Black Liquor	Blast Furnace Gas	Petroleum Coke	Oxygen Steel Furnace Gas	Coal Tar	Refinery Gas
1990	114.16	93.37	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	57.57
1995	113.39	102.17	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2000	110.05	95.52	88.62	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2005	113.50	94.23	85.24	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2010	110.26	98.56	90.01	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2011	109.48	95.10	89.11	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2012	109.29	96.65	88.89	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2013	109.09	96.18	93.57	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2014	107.63	93.15	87.70	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2015	107.63	92.38	92.64	58.66	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2016	107.41	85.32	91.37	56.04	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2017	107.24	94.50	91.55	56.02	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2018	107.55	94.12	92.75	55.74	76.97	72.28	63.07	54.63	143.00	111.83	37.35	95.33	259.60	97.53	181.87	80.67	57.57
2019	106.62	96.89	94.58	55.50	76.97	72.28	63.07	54.63	143.00	111.83	38.87	95.33	259.60	97.53	181.87	80.67	57.57
2020	104.44	91.76	94.50	53.77	76.97	72.28	63.07	54.63	143.00	111.83	39.74	95.33	259.60	97.53	181.87	80.67	57.57
2021	104.82	93.35	93.04	55.46	76.97	72.28	63.07	54.63	143.00	111.83	42.30	95.33	255.95	97.53	181.87	80.67	57.57
2022	104.68	91.71	94.98	55.97	76.97	72.78	63.07	54.63	143.00	111.83	42.76	95.33	259.60	97.53	181.87	80.67	57.57

Table 3.19 CH_4 and N_2O emission factors used for source category 1.A.1.a

(kg/TJ)

Fuel Types	CH_4	N_2O
Liquid Fuels		
Fuel Oil		
Steam	0.8	0.3
Internal Combustion	0.8	0.3
Combined Heat	0.8	0.3
Liquid Fuels		
Diesel Oil, Naphtha		
Steam	0.9	0.4
Internal Combustion	0.9	0.4
Combined Heat	0.9	0.4
Solid Fuels		
Turkish Lignite and Sub-Bituminous and Other Bituminous Coal		
Dry bottom, wall fired	0.7	0.5
Fluidised Bed	1	61
Lignite (other types of technology)	0.7	1.4
Sub-Bituminous and Coking Coal	0.7	1.4
Natural Gas		
Boiler	4	1
Gas Engine	4	1
Gas Turbine	4	1
Internal Combustion	4	1
Combined Heat	1	3
Other Fuels		
Coke Oven Gas	1	0.1
Blast Furnace Gas	1	0.1
Oxygen Steel Furnace Gas	1	0.1
Coal Tar	1	1.5
LPG	1	0.1
Refinery Gas	1	0.1
Petroleum Coke	3	0.6
Other Petroleum Products	3	0.6
Black Liquor	3	2
Industrial Waste	30	4
Biomass		
Biogas	1	1
Wood waste	11	7

Comparability and Accuracy through Nomenclature Change:

NCV of Turkish lignite differs significantly from that of the Energy Statistics Handbook and general fuel literature. It is even lower than the lowest value of lignite in all reports of the Parties. Analysis reports support this NCV data of Turkish lignite. Its average carbon content in 2022 is 29.7 kg/GJ, approaches the upper limit of 2006 IPCC Guidelines (31.3 kg/GJ). To recategorize our local lignite, we renamed it as "Turkish Lignite" to separate it from literature lignite and avoid misleading comparisons.

Carbon Capture and Storage in 1.A.1.a, if applicable

CO_2 capture from flue gases and CO_2 storage is not occurring in Türkiye, except pilot scaled research fields.

Implied Emission Factor (IEF) Trends and Comments

IEFs were examined in the following table to see time-series consistency for solid, liquid, gaseous fuels, and biomass.

Table 3.20 IEFs of fuels used for category 1.A.1.a, 1990-2022

	CO_2						CH_4		N_2O	
	Solid Fuels		Liquid Fuels		Gaseous Fuels		Biomass		Biomass	
Years	CHP	Electricity Generation	CHP	Electricity Generation	CHP	Electricity Generation	CHP	Electricity Generation	CHP	Electricity Generation
1990	-	113.41	-	76.88	58.23	58.23	-	-	-	-
1995	-	112.78	-	76.74	58.23	58.23	-	-	-	-
2000	120.03	110.51	74.03	75.55	58.23	58.23	4.80	2.92	2.13	1.65
2005	125.53	109.76	76.05	76.09	58.23	58.23	2.37	1.11	1.68	1.06
2010	130.35	107.83	70.62	76.10	58.23	58.23	4.57	1.44	3.06	1.25
2011	134.30	105.10	69.63	75.41	58.23	58.23	2.41	1.08	1.82	1.05
2012	132.06	102.89	60.18	73.23	58.23	58.23	1.11	1.10	1.03	1.05
2013	132.06	105.23	61.41	73.84	58.23	58.23	1.54	1.10	1.31	1.05
2014	111.14	100.49	64.07	75.79	58.23	58.23	2.29	1.09	1.74	1.05
2015	105.74	101.35	69.34	73.52	58.66	58.66	1.40	1.07	1.23	1.04
2016	120.84	101.98	76.97	74.00	56.04	56.04	1.38	1.04	1.22	1.02
2017	107.77	102.26	76.97	73.24	56.02	56.02	1.25	1.02	1.14	1.01
2018	119.49	101.49	76.97	76.24	55.75	55.75	1.76	1.31	1.45	1.19
2019	117.31	102.14	76.97	75.73	55.50	55.50	1.93	1.81	1.56	1.49
2020	112.17	100.79	76.97	76.36	53.77	53.77	1.63	2.98	1.38	2.18
2021	111.78	101.13	76.97	72.95	55.46	55.46	2.02	4.62	1.61	3.17
2022	114.53	101.52	76.97	72.67	55.97	55.97	1.83	4.39	1.50	3.04

IEFs of CO_2 for solid fuels range from 101 to 140 t/TJ. It is mainly because of local Turkish lignite and its share in solid fuels. Unlike literature lignite of statistics manual, Turkish lignite has a very low NCV, about one-fifth of literature. Its share in the solid fuels affects the overall IEF causing a dramatic rise and fall like its trend through the years 2001-2014 for 1.A.1.a.i.

IEFs of gaseous fuels do not change considerably over time; for example, IEFs of CO_2 range from 53.77 to 58 t CO_2/TJ. The reason for this change is the use of more gas chromatography results for analysis. After 2000 the values of CHP Generation are the same as Electricity Generation.

Fluctuations in IEFs, especially declines, are mainly owing to the increasing share of biogas. Rising in the trend, however, due to the share of black liquor. "Other Fossil Fuels" node is used for industrial wastes data reporting consisting of the clinic and hazardous wastes.

Emission estimation with T2, T3 approach using plant-specific data is compared with the T1 emission estimation using fuel data from national energy balance tables. Comparison with the T1 emission estimation results is given in Table 3.21.

Table 3.21 Comparison of GHG emissions from 1.A.1.a category ,1990-2022

	GHG emissions with plant-specific data		GHG emissions with national energy balance data		Difference	
Year	**GHG Emission (kt CO_2 eq.)**	**Fuel consumption (TJ)**	**GHG Emission (kt CO_2 eq.)**	**Fuel consumption (TJ)**	**GHG emission (kt CO_2 eq.)**	**Fuel consumption (TJ)**
1990	32 927	346 707	35 125	360 733	2 198	14 026
1995	46 005	490 230	48 729	509 424	2 724	19 194
2000	73 351	854 300	80 970	956 721	7 619	102 421
2005	85 326	1 036 864	84 951	1 067 718	- 375	30 854
2010	108 765	1 344 379	113 770	1 424 965	5 005	80 586
2011	119 897	1 478 115	125 527	1 552 324	5 630	74 209
2012	120 768	1 512 807	126 326	1 581 762	5 558	68 955
2013	115 982	1 451 358	119 915	1 519 612	3 933	68 254
2014	126 868	1 624 731	136 439	1 726 147	9 571	101 416
2015	127 836	1 591 475	127 546	1 561 850	- 290	-29 625
2016	135 424	1 644 763	135 579	1 647 281	155	2 518
2017	146 076	1 804 038	150 230	1 812 282	4 154	8 244
2018	149 923	1 791 671	156 689	1 829 058	6 766	37 387
2019	139 032	1 580 085	147 454	1 620 581	8 422	40 496
2020	131 574	1 585 675	139 637	1 621 157	8 063	35 482
2021	149 243	1 892 330	158 602	1 915 698	9 359	23 368
2022	145 027	1 737 661	156 753	1 796 001	11 726	58 340

The differences between T1 (national energy balance data) and T2, T3 (plant-specific data) results are mainly related to the solid fuels, especially NCVs of Turkish lignite. Because of the Turkish lignite's character, its NCV is lower than the lignite in literature. In plant-specific data, especially NCV of lignite changes in a wide range as 1000-5400 kg/kcal. However, in national balance tables, an average NCV value is around 2000 kcal/kg. Based on the quality of lignite used in a specific year, consumption in TJ differs from the national energy balance data. This causes differences in emissions. For example, in 2005, 42% of lignite consumed in 1A1a category has NCVs less than 1500 kcal/kg, 58% has NCVs in 1700-6000, while NCV in the national balance table is used as 1400 kcal/kg for 2005. Therefore, lignite consumption in CRT (plant-specific data) is 16,2% higher than national balance figures. On the other hand, in 2014, 70% of lignite consumption in plant-specific data has NCV less than 2000, while in national balance average NCV for lignite is used as 2100 kcal/kg. That results in a 12.1% decrease in lignite consumption in TJ (Table 3.22). With the improvements in the energy balance table in recent years, the difference between the plant-specific NCV and national balance average NCV has decreased gradually, but there was an increase 2.9% in 2022.

Table 3.22 Comparison of solid fuel consumption, 1990-2022

	Plant specific data				National energy balance data			
	Hard coal consumption		Lignite consumption		Hard coal consumption		Lignite consumption	
Year	(kt)	(TJ)	(kt)	(TJ)	(kt)	(TJ)	(kt)	(TJ)
1990	474	7 761	29 884	205 169	474	7 764	29 884	202 692
1995	1 246	15 866	39 815	275 859	1 245	16 232	39 815	277 051
2000	1 942	30 130	52 539	371 196	1 942	30100	52540	373 143
2005	5 174	108 533	47 414	324 826	5 171	108 531	47 413	272 791
2010	6 935	154 215	55 437	389 958	6 934	154 272	55 436	391 552
2011	10 116	230 759	60 271	423 208	10 117	247 412	60 271	423 429
2012	11 760	287 433	54 584	378 208	11 761	287 616	54 586	378 692
2013	11 707	279 108	45 919	327 977	11 707	279 238	45 919	328 369
2014	13 826	332 019	51 967	363 512	14 039	337 447	57 411	407 424
2015	16 126	389 644	48 820	350 379	16 071	388 577	48 755	349 232
2016	17 966	436 847	58 974	420 041	17 966	436 657	58 974	424 445
2017	19 485	466 990	62 837	432 048	19 485	466 466	62 837	438 039
2018	23 437	555 837	71 990	482 560	23 437	555 596	71 990	487 535
2019	23 321	548 539	74 397	505 425	23 320	547 944	74 396	512 511
2020	24 235	553 834	61 471	407 980	23 653	555 774	59 835	412 198
2021	21 470	492 101	71 448	474 748	21 470	491 515	71 448	480 125
2022	24 404	566 910	77 677	507 514	24 161	553 125	77 677	521 981

Uncertainties and Time-Series Consistency

AD's have been compiled from all public electricity and heat production facilities by Turkish Electricity Transmission Company (TEİAŞ) via survey. As a result of the change made in the activity data source, no bias in total electricity production was published in the Activity Report of TEİAŞ. On the other hand, compared to General Energy Balance Sheets AD of 1.A.1.a category had some bias in the amount of fuel used. Experts of MENR determined uncertainties. For hard coal and Turkish lignite, there is no bias for AD. There is no bias in 2022.

CO_2 emission factors uncertainties

Solid fuels: Turkish lignite, other bituminous coal, sub-bituminous coal tar, coke oven gas, blast furnace gas, and oxygen steel furnace gas have been used as solid fuels in 1.A.1.a category, and combined uncertainty for solid fuels was calculated as 3.5% with Approach 1 method.

Liquid fuels: Residual fuel oil, diesel oil, naphtha, LPG, petroleum coke, refinery gas, and other oil products have been used as liquid fuels in 1.A.1.a category. The combined uncertainty for these liquid fuels was calculated as 4.24% with the Approach 1 method.

Gaseous Fuels: Natural gas has been used as gaseous fuels in 1.A.1.a category, and uncertainty for gaseous fuels was calculated as 1.5% with the Approach 1 method.

Biomass: Default EF in 2006 IPCC Guidelines on page 1.26 in the landfill gas distribution figure the most frequent EF is 47 000 kg/TJ. The default value that we used for biomass is 54 600 kg/TJ. Bias in between is 13.91% that was taken as uncertainty for biogas. Default EF in 2006 IPCC Guidelines on page 1.27 in the wood/wood waste distribution figure the most frequent EF is 103 000 kg/TJ. The default value that we used for wood/wood waste is 112 000 kg/TJ. Bias in between is 8% that was taken as uncertainty for wood/wood waste. These two biomass fuels' uncertainties were combined using a weighted average according to the generated heat amount. So the combined uncertainty for biomass is 9.57%.

Other Fossil Fuels: Default EFs were taken from 2006 IPCC Guidelines for industrial wastes (mainly composed of hazardous and clinic waste) and waste oils. On the other hand, there was no default uncertainty value for industrial waste EF throughout the guideline.

EFs uncertainty for CH_4 and N_2O were taken from 2006 IPCC Guidelines Vol.2 page 2.38 Table 2.12 and considered 100% (mid-value in the range).

Recalculation

There is no recalculation for this category.

Planned Improvement

There is no planned improvement in this category.

3.2.4.2. Petroleum refining (Category 1.A.1.b)

Source Category Description:

All fossil fuels consumed for petroleum refineries process operations were covered in CRT category 1.A.1.b. However autoproducers within the refineries were included in the 1.A.1.a category. The share of GHG emissions as CO_2 eq. from petroleum refining in energy industries sector (1A1) was 5.7% in 2022 and it was also 12% in 1990.

Table 3.23 Emissions from petroleum refining, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1A1 category (%)
1990	4 772	0.062	0.007	4 775	73 929	12.0
1995	5 761	0.075	0.009	5 765	89 258	10.8
2000	5 329	0.070	0.008	5 333	82 563	6.7
2005	6 385	0.084	0.010	6 389	98 921	6.9
2010	4 897	0.064	0.007	4 901	75 869	4.2
2011	5 234	0.068	0.008	5 238	81 089	4.1
2012	5 539	0.072	0.008	5 543	85 823	4.3
2013	5 403	0.071	0.008	5 407	83 708	4.4
2014	5 020	0.066	0.008	5 024	77 784	3.8
2015	6 888	0.090	0.010	6 893	106 721	5.0
2016	7 101	0.093	0.011	7 106	110 020	4.9
2017	7 138	0.093	0.011	7 144	110 602	4.6
2018	6 224	0.106	0.013	6 231	96 319	3.9
2019	8 136	0.095	0.011	8 142	115 928	5.4
2020	8 052	0.098	0.011	8 058	126 772	5.7
2021	7 756	0.093	0.010	7 761	128 235	4.9
2022	8 826	0.117	0.015	8 834	136 929	5.7

Total emissions from petroleum refining were increased by 1 072 kt CO_2 eq. from 2021 to 2022 (13.8% of increase).

Methodological Issues:

Emissions from petroleum refining (CRT 1.A.1.b) were calculated according to 2006 IPCC T3 approach by TurkStat for the years 2018-2022. Fuel consumption, NCVs and carbon content and CO_2 emissions are taken from plants which is also reported to the Directorate of Climate Change. CH_4 and N_2O emissions from CRT category 1.A.1.b, have been estimated by using refineries total fuel consumption and average NCVs for refineries and 2006 IPCC default EFs. For the year 1990-2017; emissions were estimated by using total oil refined.

Uncertainties and Time-Series Consistency:

All refineries are covered in the inventory. AD uncertainty of both liquid and gaseous fuels for refineries is considered 2% as indicated in table 2.15 of 2006 IPCC Guidelines Vol.2. Since AD for refineries have been taken directly from the refineries, uncertainty level for survey data were considered and to be conservative the maximum uncertainty value was used.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1.A.1.b category was performed on the basis of QA/QC plan. It was first confirmed with refinery authorities that AD do not include the autoproducers consumption in the refinery. Calorific values provided by the refinery are checked with national average NCVs of fuels to ensure the use of NCVs in emission estimation. Also carbon content of fuels provided by the refinery checked with IPCC default values to ensure they are in the range. Emissions from refineries were also calculated by using national energy balances to compare results. There is 23% difference between the results for the year 2022. This difference may come from process gases which are used as fuel in plants and they can not be seen in national balances table which are Plt 47 Hydrocracker Fuel Gas, Vacuum Off Gas, PSA off gas, CCR coke, FCC coke, VDU off gas, Klaus tail gas, Vent Gas.

Recalculation:

In this submission, CO_2 emissions from plants were taken from plants. Regulation on "Greenhouse Gases Emission Monitoring" went into force on April 25, 2012 with the publication of 28274 numbered official gazette. And plants started to report their 2018 emissions in 2020. 2018-2022 CO_2 emissions were taken directly from plants and 1990-2017 emissions were recalculated based on the amount of petroleum refined.

Planned Improvement:

There is no planned improvement.

3.2.4.3. Manufacture of solid fuels and other energy industries (Category 1.A.1.c)

Source Category Description:

All coke production facilities were covered in CRT category 1.A.1.c. The share of GHG emissions as CO_2 eq. from manufacture of solid fuels category in 1A1 category was 1.3% in 2022 while it was 5.0% in 1990.

Table 3.24 Emissions from category 1.A.1.c, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1A1 Category (%)
1990	1 997	0.016	0.005	1 999	15 752	5.0
1995	1 429	0.012	0.001	1 429	11 623	2.7
2000	1 432	0.011	0.001	1 433	10 944	1.8
2005	1 289	0.013	0.003	1 291	12 074	1.4
2010	1 721	0.011	0.001	1 721	11 474	1.5
2011	1 904	0.012	0.001	1 905	11 506	1.5
2012	1 988	0.012	0.001	1 989	12 386	1.6
2013	1 933	0.014	0.001	1 934	13 868	1.6
2014	2 004	0.014	0.001	2 004	14 370	1.5
2015	2 253	0.016	0.002	2 254	15 707	1.6
2016	2 061	0.014	0.001	2 062	13 592	1.4
2017	2 443	0.014	0.001	2 444	14 181	1.6
2018	2 467	0.014	0.001	2 468	14 003	1.6
2019	2 411	0.014	0.002	2 412	13 824	1.6
2020	2 226	0.014	0.001	2 227	14 050	1.6
2021	2 347	0.014	0.001	2 347	13 930	1.5
2022	2 075	0.014	0.001	2 076	13 800	1.3

Total emissions from manufacture of solid fuels and other energy industries were decreased by 271 kt CO_2 eq. from 2021 to 2022 (11.6% of decrease) due to decrease of fuel consumption.

Methodological Issues:

Emissions from manufacture of solid fuels (CRT 1.A.1.c) were calculated according to 2006 IPCC T3 approach by TurkStat. Coke production in integrated iron and steel production plants have been considered in this category. Coke oven gas, blast furnace gas, and rarely natural gas have been used for heating of coke ovens. Plant specific fuel consumption, NCVs and carbon content of fuels were compiled from each plant. CO_2 emissions from 1.A.1.c were calculated by using plant specific AD, carbon contents of fuels and 2006 IPCC default oxidation rates. CH_4 and N_2O emissions from CRT category 1.A.1.c, have been estimated by using plant specific fuel consumption and NCVs and 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

All coke production facilities were covered in the inventory. AD uncertainty for solid fuels for coke plants were considered 2% as indicated in Table 2.15 of 2006 IPCC Guidelines Vol.2. Since AD have been taken directly from the coke plants, uncertainty level for survey data were considered and to be conservative the maximum uncertainty value was used.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1.A.1.c category was performed on the basis of QA/QC plan. Calorific values provided by the coke plants checked with national average NCVs of fuels to ensure the use of NCVs in emission estimation. Also carbon content of fuels provided by the coke plants compared with 2006 IPCC default values. Carbon mass balances on integrated iron and steel plants is done in the IPPU sector as a part of QC/QA of activity data. This control also assures the fuel consumption in the coke ovens.

Recalculation:

Emissions for the years 1990-1993 and 2005-2020 were recalculated due to the calculation error. The effect of error varies between -6.25% and 3.7%.

Planned Improvement:

Recently carbon mass balance on integrated iron and steel plants in cooperation with sector experts have been done and good results are taken. There is no planned improvement at the moment.

3.2.5. Manufacturing industries and construction (Category 1.A.2)

Source Category Description:

This source category consists of manufacturing industries sectors. IPCC categorizes manufacturing industry as iron and steel, nonferrous metal, chemicals, pulp, paper and print, food processing, beverages and tobacco, non-metallic minerals and other industry. Until 2015 sectoral breakdown of national energy balance tables are not fully in line with CRT categories. In the national energy balance tables, pulp, paper and print sector were presented separately from 2011 onward. It was presented under "other industries (1.A.2.g)" category before 2011. Food processing category included only sugar industry for 1990-2010 periods. From 2011 onward all food processing industries were covered but beverages and tobacco industry were still included under "other industries (1.A.2.g)" category. However, starting from 2015, national energy balance tables are detailed and provided energy consumption for all economical activities so GHG emissions are allocated in line with CRT category.

Table 3.25 Fuel combustion emissions from manufacturing industry and construction, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in fuel combustion (1A) category (%)
1990	37 004	2.168	0.347	37 157	386 908	27.0
1995	39 843	2.064	0.336	39 990	452 068	24.2
2000	57 657	3.905	0.609	57 928	629 742	27.3
2005	62 731	3.846	0.595	62 996	743 394	26.2
2010	52 120	3.001	0.461	52 326	639 363	18.6
2011	52 380	2.913	0.443	52 579	662 028	17.4
2012	60 821	3.278	0.499	61 045	760 755	19.5
2013	52 772	2.915	0.446	52 972	648 612	17.6
2014	54 233	2.926	0.444	54 433	680 149	17.1
2015	59 359	3.227	0.487	59 578	765 682	17.6
2016	59 840	3.292	0.498	60 064	785 911	17.1
2017	59 958	3.173	0.478	60 174	780 500	16.1
2018	59 311	4.263	0.619	59 595	814 100	16.3
2019	55 858	4.419	0.634	56 150	765 706	15.7
2020	61 277	4.768	0.688	61 593	824 069	17.1
2021	68 161	5.727	0.815	68 537	929 649	17.4
2022	65 092	5.627	0.805	65 463	867 039	16.9

There is a sharp decrease in the emissions in 2008. This is due to the global economic downturn in 2008. GHG emissions from 1.A.2 category is 65.5 Mt CO_2 eq. in 2022 which is 17% of total fuel combustion and 11.7% of total national emissions (excluding LULUCF), whereas GHG emissions from 1.A.2 category was 37.2 Mt CO_2 eq. which is 27% of total fuel combustion and 16.3% of total national emissions (excluding LULUCF) in 1990. GHG emissions from 1.A.2 category have been decrease by 3 Mt CO_2 eq. (-4.5%) from 2021 to 2022.

Table 3.26 GHG emissions from manufacturing industry and construction, 1990-2022

(kt CO_2 eq.)

Year	Total	Iron and steel	Non-ferrous metals	Chemicals	Pulp, paper and print	Food processing beverages and tobacco	Non-metallic minerals	Other industries
1990	37 157	6 685	1 088	4 892	IE	2 909	8 260	13 322
1995	39 990	5 591	1 756	4 961	IE	1 685	8 792	17 204
2000	57 928	6 566	1 952	3 762	IE	2 143	9 248	34 257
2005	62 996	5 482	2 225	5 345	IE	2 119	14 880	32 945
2010	52 326	3 657	1 153	2 899	IE	880	21 355	22 381
2011	52 579	3 990	755	3 139	776	3 378	25 341	15 199
2012	61 045	4 380	1 173	4 646	743	3 528	27 934	18 641
2013	52 972	4 638	760	3 942	766	3 603	26 370	12 892
2014	54 433	4 992	989	3 704	888	3 322	28 253	12 284
2015	59 578	5 287	1 199	6 688	963	4 359	29 950	11 132
2016	60 064	4 190	1 407	6 070	1 076	4 961	31 628	10 732
2017	60 174	4 327	1 136	5 317	942	4 921	32 573	10 958
2018	59 595	4 215	809	7 031	982	5 079	30 214	11 265
2019	56 150	4 620	774	6 404	1 023	5 180	27 048	11 102
2020	61 593	5 660	694	6 839	1 270	5 864	31 013	10 253
2021	68 537	5 846	867	8 296	1 281	6 331	35 006	10 909
2022	65 463	5 153	870	7 820	1 356	6 484	33 693	10 086

Non-metallic minerals and chemicals and other industries are the main contributors for GHG emissions in 1.A.2 category. The share of non-metallic minerals is 51.5%.

Table 3.27 Contribution of subsectors of manufacturing industries and construction, 2021-2022

	Emissions ($kt\ CO_2$ eq.)		Changes from 2021 to 2022		Share in manufacturing industry (%)	
	2021	2022	($kt\ CO_2$ eq.)	(%)	2021	2022
1.A.2 Total	68 537	65 463	- 3 074	-4.5	100.0	100.0
Iron and steel	5 846	5 153	- 693	-11.9	8.5	7.9
Non-ferrous metals	867	870	3	0.3	1.3	1.3
Chemicals	8 296	7 820	- 476	-5.7	12.1	11.9
Pulp, paper and print	1 281	1 356	75	5.9	1.9	2.1
Food processing, beverages and tobacco	6 331	6 484	153	2.4	9.2	9.9
Non-metallic minerals	35 006	33 693	- 1 313	-3.8	51.1	51.5
Other industries	10 909	10 086	- 822	-7.5	15.9	15.4

GHG emissions from 1.A.2 category have been decreased by 4.5% between 2021 and 2022.

Manufacturing industry and construction category is a key category in terms of emission level and emission trend of CO_2 emissions from liquid, solid and gaseous fuels in 2022. It is also a key category in terms of emission level of CO_2 from other fossil fuels

Methodological Issues:

GHG emissions from 1.A.2 sector are calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data are taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EFs are used when available, otherwise default CO_2 EFs are used. All CO_2 EFs are given in table 3.18 under 3.2 Fuel Combustion Sector. All CH_4 and N_2O EFs are default. The default CH_4 and N_2O EFs for 1A2 sector are tabulated below. Due to the different types of fuels among many industrial areas and varying composition of natural gas purchased by the countries, EFs show significant interannual changes.

Table 3.28 Defualt CH_4 and N_2O EFs for 1A2 sector

	Emission Factors		Source
Sub Sectors	**CH_4 (kg/TJ)**	**N_2O(kg/TJ)**	
1A2 sector			
Coal products	10	1.5	Table 2.3
LPG	1	0.1	Table 2.3
Other Petroluem products	3	0.6	Table 2.3
Derived gases	1	0.1	Table 2.3
Wood	30	4	Table 2.3
Natural gas	1	0.1	Table 2.3

Data on waste incineration for energy recovery have been compiled by TurkStat via survey until 2015 inventory year, after 2015 the waste incineration data were supplied by Directorate of Energy Efficiency and Environment. The list of all waste incineration facilities having waste incineration licenses was determined from the MoEU. Then the amount of waste incinerated and NCVs as MJ/kg by waste types were compiled from all facilities listed by the MoEU. Plant specific waste incineration data and NCVs were used in the GHG estimation. But, 2006 IPCC default EFs were used for CO_2, CH_4 and N_2O emission estimation.

Uncertainties and Time-Series Consistency:

The AD for manufacturing industry sector are completely taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were given under subcategories.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O. The same uncertainties were used for all subcategories of 1A2 except 1A2a.

Source-Specific QA/QC and Verification:

Quality control for 1A2 category was performed on the basis of QA/QC plan. Country specific carbon content of fuels is checked with IPCC default values to ensure that they are in range. Reasonability of IEFs are compared with the previous annual submission and with the 2006 IPCC Guidelines.

The table shows the change in the CO_2 IEFs in the time series for liquid and solid fuels.

Table 3.29 CO_2 implied emission factors for 1A2 category

Year	Liquid	Solid	Gaseous
1990	77.8	117.7	55.5
1995	79.4	117.9	55.5
2000	79.9	105.5	55.5
2005	81.8	103.5	55.5
2010	85.0	106.4	55.6
2011	84.7	104.2	56.6
2012	87.0	106.0	55.5
2013	88.9	105.6	55.5
2014	91.2	103.9	55.5
2015	92.0	99.0	55.7
2016	93.1	92.5	55.7
2017	93.2	97.7	55.6
2018	94.3	97.4	55.3
2019	93.8	99.1	53.7
2020	94.3	97.3	55.7
2021	92.8	98.2	55.4
2022	93.4	98.1	55.7

It can be seen on the table that CO_2 IEF for liquid fuels is increasing in the time series. This is because the share of petroleum coke usage has been increased since 1990 while the share of other petroleum products has been decreased since 1990.
On the other hand, it can be seen that CO_2 IEF for solid fuels is decreasing in the time series. This is because the share of lignite has been decreased since 1990 while the share of coking coal and coke has been increased since 1990.

Recalculation:

1.A.2.f recalculated due to the revision AD for the year 2019-2021. Recalculation effected emission between -7% and -5%.

Planned Improvement:

Prior to 2011 several manufacturing sectors that have their own categories (pulp, paper & print; non-metallic minerals; food processing, beverages & tobacco) were not fully separated out in the national energy balance and therefore some or all of the emissions from these categories were reported under section 1A2g. This is because in the calculation of 1A2 subcategories the national energy balance tables are used and national energy balance tables are not created as time series. All relevant institutions are working together in order to overcome this inconsistency problem.

3.2.5.1. Iron and steel industries (Category 1.A.2.a)

Source Category Description:

The source categories cover emissions from the iron and steel industries including primary and secondary steel producers and rolling mill plants.

Currently there are, 3 integrated facilities producing primary steel and 27 EAF mills producing secondary steel in Türkiye. The share of GHG emissions as CO_2 eq. from 1A2a in total 1A2 was 7.9% in 2022 while it was 18.0% in 1990.

Table 3.30 Fuel combustion emissions from iron and steel industry, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 (%)
1990	6 678	0.10	0.017	6 685	51 756	18.0
1995	5 584	0.10	0.017	5 591	46 104	14.0
2000	6 559	0.09	0.016	6 566	49 855	11.3
2005	5 478	0.06	0.009	5 482	37 766	8.7
2010	3 652	0.08	0.012	3 657	47 148	7.0
2011	3 987	0.06	0.006	3 990	56 485	7.6
2012	4 377	0.05	0.005	4 380	50 211	7.2
2013	4 635	0.06	0.006	4 638	59 556	8.8
2014	4 989	0.06	0.006	4 992	61 286	9.2
2015	5 282	0.07	0.011	5 287	71 979	8.9
2016	4 186	0.06	0.008	4 190	63 997	7.0
2017	4 322	0.07	0.009	4 327	71 184	7.2
2018	4 207	0.12	0.016	4 215	70 018	7.1
2019	4 615	0.08	0.010	4 620	75 977	8.2
2020	5 655	0.09	0.010	5 660	83 337	9.2
2021	5 841	0.09	0.010	5 846	87 842	8.5
2022	5 148	0.08	0.009	5 153	80 501	7.9

Total emissions from iron and steel subcategory was decreased by 693 kt CO_2 eq. from 2021 to 2022 (11.9% of decrease) due to decrease of fuel consumption.

Methodological Issues:

GHG emissions from 1A2a sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EF are used when available, otherwise default CO_2 EF are used. All CH_4 and N_2O EFs are default.

Integrated iron and steel plants are energy intensive and complex plants. All emission sources were identified together with experts from integrated facilities and emissions are allocated under appropriate CRT categories. Allocation is made in the following way;

- Emissions from electricity generation in auto-producer is considered under Energy-1.A.1.a public electricity and heat production category (based on the reallocation of autoproducers as explained above under source category description of section 3.2.5),
- Emissions from the heating of coke ovens (for coke production) is considered under Energy-1.A.1.c (manufacture of solid fuels) category,
- Emissions from the heating of rolling mills and other miscellaneous combustion emissions are considered under Energy-1.A.2.a iron and steel industry category,

- All carbonaceous fuels (including coke as reducing agent) used in blast furnaces and sinter production are considered under IPPU-2.C.1 iron &steel production.

Uncertainties and Time-Series Consistency:

Plant specific AD is used for integrated iron and steel production facilities. The AD for EAFs is taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR and TurkStat. AD uncertainties were determined as 10 % for liquid, gaseous, and solid fuels.

EFs uncertainty was determined by sector experts from TurkStat. Uncertainty values were determined as 25% for CO_2. EFs uncertainty for CH_4 and N_2O was taken from 2006 IPCC Guidelines Vol.2 page 2.38 Table 2.12 and considered as 100% (mid value in the range).

Source-Specific QA/QC and Verification:

Quality control for 1A2a category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined.

Recalculations:

There is recalculation due the the minor changes of EF parameters and resulted as 1.4% change in 2018 emissions.

Planned Improvement:

There is no planned improvement specific to this category.

3.2.5.2. Non-ferrous metal (Category 1.A.2.b)

Source Category Description:

The share of GHG emissions as CO_2 eq. from 1.A.2.b in total manufacturing industry fuel combustion was 1.3% in 2022 while it was 2.9% in 1990.

Table 3.31 Fuel combustion emissions from non-ferrous metals, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	1 084	0.05	0.009	1 088	13 187	2.9
1995	1 750	0.08	0.014	1 756	22 300	4.4
2000	1 945	0.10	0.016	1 952	25 668	3.4
2005	2 219	0.08	0.013	2 225	33 266	3.5
2010	1 151	0,02	0,003	1 153	20 089	3.6
2011	754	0,02	0,002	755	13 016	3.3
2012	1 171	0,03	0,003	1 173	20 393	0.5
2013	759	0,02	0,002	760	13 379	2.1
2014	987	0,02	0,002	989	17 371	2.2
2015	1 197	0.03	0.004	1 199	20 103	2.0
2016	1 404	0.05	0.006	1 407	22 925	2.3
2017	1 134	0.04	0.005	1 136	18 034	1.9
2018	807	0.03	0.004	809	12 688	1.4
2019	771	0.04	0.005	774	13 486	1.4
2020	693	0.02	0.003	694	11 410	1.1
2021	866	0.03	0.004	867	14 381	1.3
2022	868	0.04	0.005	870	13 419	1.3

The increase in total emissions of 1.A.2.b category from 2021 to 2022 is 2.6 kt CO_2 eq. (0.3% of increase).

Methodological Issues:

GHG emissions from 1.A.2.b sector were calculated by using 2006 IPCC Tier 1 and Tier 2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EFs are used for emission estimation. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs. GHG emissions from biomass were estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 21.21% for liquid, gaseous and solid fuels.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1.A.2.b category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined. CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC Guidelines but are changing based on fuel mix used in the sector

Recalculation:

There is recalculation for the whole time series due to the revision of the country specific emission factor for solid fuels. Recalculation effected emission less than 0.1%.

Planned Improvement:

There is no planned improvement specific to this category.

3.2.5.3. Chemicals (Category 1.A.2.c)

Source Category Description:

The source category includes manufacture of chemicals, fertilizer, basic pharmaceutical products and rubber and plastic manufacturing. The share of GHG emissions as CO_2 eq. from 1.A.2.c in total manufacturing industry was 11.9% in 2022 while it was 13.2% in 1990.

Table 3.32 Fuel combustion emissions from chemicals, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	4 875	0.24	0.040	4 892	62 789	13.2
1995	4 948	0.17	0.030	4 961	71 612	12.4
2000	3 751	0.15	0.027	3 762	51 629	6.5
2005	5 334	0.16	0.026	5 345	82 163	8.5
2010	2 889	0.14	0.023	2 899	40 314	5.5
2011	3 132	0.12	0.016	3 139	49 224	6.0
2012	4 635	0.16	0.023	4 646	74 005	7.6
2013	3 929	0.19	0.027	3 942	57 487	7.4
2014	3 692	0.19	0.026	3 704	54 713	6.8
2015	6 672	0.26	0.034	6 688	106 985	11.2
2016	6 054	0.26	0.035	6 070	97 036	10.1
2017	5 306	0.18	0.023	5 317	87 051	8.8
2018	7 010	0.33	0.044	7 031	111 968	11.8
2019	6 385	0.30	0.040	6 404	101 747	11.4
2020	6 820	0.30	0.041	6 839	107 599	11.1
2021	8 276	0.32	0.043	8 296	134 080	12.1
2022	7 799	0.34	0.046	7 820	122 714	11.9

The decrease in total emissions of 1.A.2.c category from 2021 to 2022 is 476 kt CO_2 eq. (5.7% of decrease). The decrease in GHG emission of this category is related to the decrease in production of main contributing sectors.

Methodological Issues:

GHG emissions from 1.A.2.c category were calculated using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Data on waste incineration for energy recovery have been compiled by TurkStat via official letter. The amount of waste incinerated and NCVs as MJ/kg by waste types were compiled from the facilities. Plant specific waste incineration data and NCVs were used in the GHG estimation.

Country specific CO_2 EFs are used for emission estimation. GHG emissions from waste incineration were estimated by using 2006 IPCC default EFs. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD was taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 15.81% for liquid, gaseous and solid fuels.

For other fossil fuels it was considered 2% as indicated in table 2.15 of 2006 IPCC Guidelines Vol.2. Since AD for waste incineration have been taken directly from the petrochemical facility, uncertainty level for survey data was considered and to be conservative the maximum uncertainty value was used.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% was taken (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A2c category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined. Also country specific carbon content of fuels is checked with IPCC default values to ensure they are in the range. Reasonability of IEFs is compared with the previous annual submission and with the 2006 IPCC Guidelines.

Recalculation:

There is no recalculation.

Planned Improvement:

There is no planned improvement specific to this category.

3.2.5.4. Pulp, paper and print (Category 1.A.2.d)

Source Category Description:

The fuel consumption for production of pulp and paper products was separated in the national energy balance tables in 2011. Therefore, emissions from this sector was evaluated under the 1.A.2.g other industries category before 2011. In 2015 national energy balance, print sector is also covered under 1.A.2.d which is included under 1.A.2.g previously. The share of GHG emissions as CO_2 eq. from 1.A.2.d in total manufacturing industry fuel combustion was 2.1% in 2022.

Table 3.33 Fuel combustion emissions from pulp, paper and print, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990-2010	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2011	774	0.04	0.005	776	11 127	1.5
2012	740	0.04	0.006	743	9 972	1.2
2013	764	0.04	0.005	766	11 118	1.4
2014	885	0.05	0.007	888	12 315	1.6
2015	960	0.06	0.008	963	12 946	1.6
2016	1 072	0.06	0.008	1 076	15 156	1.8
2017	939	0.05	0.007	942	13 014	1.6
2018	977	0.07	0.010	982	13 303	1.6
2019	1 019	0.06	0.009	1 023	14 181	1.8
2020	1 264	0.08	0.012	1 270	17 481	2.1
2021	1 275	0.09	0.013	1 281	17 234	1.9
2022	1 349	0.12	0.017	1 356	16 441	2.1

The increase in total emissions of 1.A.2.d category from 2021 to 2022 is 75 kt CO_2 eq. (5.9% of increase).

Methodological Issues:

GHG emissions from 1.A.2.d sector were calculated using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EFs are used for emission estimation. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated using 2006 IPCC default EFs. GHG emissions from biomass were estimated using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 18% for liquid, gaseous and solid fuels.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1.A.2.d category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined.

Recalculation:

There is no recalculation in this sector.

Planned Improvement:

There is no planned improvement specific to this category.

3.2.5.5. Food processing, beverages and tobacco (Category 1.A.2.e)

Source Category Description:

The source category includes food processing, manufacturing of beverages, tobacco industry and sugar industry. In the national energy balance tables, the fuel consumption for food processing sector was separated in 2011. For 1990-2010 period only sugar industry, 2011-2014 period all food processing industry were covered under this category but fuel consumption for beverages and tobacco industry cannot be separated and was considered under the section other industries (1.A.2.g). In 2015 national energy balance table, the beverages and tobacco industry are also included under 1.A.2.e category.

The share of GHG emissions as CO_2 eq. from 1.A.2.e in total 1.A.2 GHG emissions was 7.8% in 1990 while it was 9.9% in 2022.

Table 3.34 Fuel combustion emissions from 1A2e category, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	2 892	0.24	0.04	2 909	27 656	7.8
1995	1 676	0.13	0.02	1 685	16 894	4.2
2000	2 130	0.19	0.03	2 143	20 673	3.7
2005	2 108	0.16	0.02	2 119	22 373	3.4
2010	877	0.05	0.01	880	12 244	1.7
2011	3 364	0.21	0.03	3 378	43 421	6.4
2012	3 515	0.21	0.03	3 528	46 695	5.8
2013	3 591	0.19	0.03	3 603	50 942	6.8
2014	3 310	0.19	0.03	3 322	46 330	6.1
2015	4 342	0.26	0.04	4 359	58 490	7.3
2016	4 943	0.28	0.04	4 961	69 245	8.3
2017	4 902	0.28	0.04	4 921	67 426	8.2
2018	5 047	0.49	0.07	5 079	77 611	8.5
2019	5 156	0.36	0.05	5 180	75 449	9.2
2020	5 838	0.41	0.06	5 864	83 228	9.5
2021	6 299	0.49	0.07	6 331	90 310	9.2
2022	6 452	0.48	0.07	6 484	83 599	9.9

Total GHG emission in 1.A.2.e category increased 153 kt CO_2 eq. (2.4% of increase) from 2021 to 2022.

Methodological Issues:

GHG emissions from 1.A.2.e sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EFs are used for emission estimation. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 18% for solid fuels, 5.00% for Liquid fuels and 14.14% for gaseous fuels.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% was taken (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A2e category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined.

Recalculation:

There is recalculation in this sector due to the revision of waste used as fuel between 0.02% and 0.3%

Planned Improvement:

There is no planned improvement specific to this category.

3.2.5.6. Non-metallic minerals (Category 1.A.2.f)

Source Category Description:

Glass, cement and ceramic production is covered under this category. For 1990-2010 period only cement industry was covered under this category and fuel consumption for glass and ceramic production were considered under the other industries (1.A.2.g) for that period.

In Türkiye, some cement plants have waste incineration license which is given by MoEU. They use waste as alternative fuels and also raw material. Wastes co-incinerated by license are: waste plastics, used tires, waste oils, industrial sludge, tank bottom sludge and sewage sludge, etc. Waste incineration has been carried out since 2004 in cement industry. Waste incineration emissions from cement industry are covered under this category.

1.A.2.f category is energy intensive sector. The share of GHG emissions as CO_2 eq. from 1.A.2.f in total manufacturing industry GHG emission was 51.5% in 2022 while it was 22.2% in 1990.

Table 3.35 Fuel combustion emissions from non-metallic minerals, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	8 216	0.64	0.100	8 260	85 781	22.2
1995	8 750	0.61	0.097	8 792	86 732	22.0
2000	9 204	0.63	0.100	9 248	94 531	16.0
2005	14 810	0.99	0.158	14 880	152 922	23.6
2010	21 240	1.66	0.258	21 355	209 775	40.8
2011	25 214	1.84	0.283	25 341	273 446	48.2
2012	27 797	2.00	0.309	27 934	298 718	45.8
2013	26 240	1.88	0.292	26 370	277 274	49.8
2014	28 122	1.89	0.295	28 253	309 282	51.9
2015	29 810	2.03	0.315	29 950	332 379	50.3
2016	31 482	2.09	0.330	31 628	360 842	52.7
2017	32 430	2.05	0.323	32 573	362 747	54.1
2018	30 048	2.44	0.370	30 214	351 235	50.7
2019	26 873	2.61	0.384	27 048	313 700	48.2
2020	30 823	2.82	0.419	31 013	361 131	50.4
2021	34 759	3.71	0.540	35 006	408 465	51.1
2022	33 458	3.53	0.516	33 693	390 293	51.5

The decrease in total GHG emission of 1.A.2.f category is 1 313 kt CO_2 eq. (3.8% of decrease) from 2021 to 2022.

Methodological Issues:

GHG emissions from 1.A.2.f sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Data on waste incineration for energy recovery have been compiled by TurkStat via survey until 2015 inventory year, after 2015 the waste incineration data were supplied by General Directorate of Renewable Energy. The amount of waste incinerated and NCVs as MJ/kg by waste types were compiled from the facilities. Plant specific waste incineration data and NCVs were used in the GHG estimation.

Country specific CO_2 EFs are used for emission estimation. GHG emissions from waste incineration and biomass were estimated by using 2006 IPCC default EFs. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 25.5% solid fuels, 27.8%for liquid fuels, and 29.2% for gaseous fuels.

For other fossil fuels and biomass, it was considered 2% as indicated in table 2.15 of 2006 IPCC Guidelines Vol.2. Since AD for waste and sewage sludge incineration data have been taken directly from the cement producers uncertainty level for survey data were considered and to be conservative the maximum uncertainty value was used.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1.A.2.f category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined.

CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC guidelines but are changing based on fuel mix used in the sector.

The emissions from this sector is compared with the production data of cement, glass and ceramics industry. The emissions and production data is found to be consisting with each in concerning the time series.

Recalculation:

There is recalculation in 2019-2021 emission and resulted as 5-7% change for these years

Planned Improvement:

There is no planned improvement specific to this category.

3.2.5.7. Other industries (Category 1.A.2.g)

Source Category Description:

The manufacturing industry sectors which are not specified above are covered in this category. Based on the improvements in the sectoral breakdown of national energy balance the coverage of this category varies over times. As explained under section 3.2.5.4 and 3.2.5.5 some of the categories are included under 1.A.2.g category until 2011. In 2016 national energy balance tables provide complete sectoral breakdown of all economic activities, the coverage of this category is in line with CRT categorization.

The share of GHG emissions as CO_2 eq. from 1.A.2.g in total manufacturing industry fuel combustion was 15.4% in 2022 while it was 35.9% in 1990.

Table 3.36 Fuel combustion emissions from other industries, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	13 258	0.91	0.145	13 322	145 738	35.9
1995	17 135	0.97	0.158	17 204	208 427	43.0
2000	34 068	2.75	0.422	34 257	387 385	59.1
2005	32 781	2.40	0.364	32 945	414 903	52.3
2010	22 310	1.05	0.158	22 381	309 794	42.8
2011	15 154	0.64	0.101	15 199	215 309	28.9
2012	18 587	0.79	0.123	18 641	260 761	30.5
2013	12 854	0.54	0.087	12 892	178 856	24.3
2014	12 248	0.53	0.080	12 284	178 853	22.6
2015	11 097	0.52	0.076	11 132	162 800	18.7
2016	10 699	0.50	0.072	10 732	156 710	17.9
2017	10 925	0.50	0.070	10 958	161 044	18.2
2018	11 215	0.77	0.106	11 265	177 276	18.9
2019	11 039	0.97	0.135	11 102	171 165	19.8
2020	10 185	1.05	0.145	10 253	159 883	16.6
2021	10 845	0.99	0.136	10 909	177 337	15.9
2022	10 019	1.04	0.144	10 086	160 072	15.4

Total GHG emission in 1.A.2.g category decreased 822 kt CO_2 eq. (7.5% of decrease) from 2021 to 2022.

Methodological Issues:

GHG emissions from 1.A.2.g sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EFs are used for emission estimation. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 70.71% for liquid, gaseous and solid fuels.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1.A.2.g category was performed on the basis of QA/QC plan.CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC Guidelines.

Recalculation:

There is recalculation for the year 2019-2021 due to the revision of AD. Recalculation effected emission between 7% and 4.7%.

Planned Improvement:

There is no planned improvement specific to this category.

3.2.6. Transport (Category 1.A.3)

Estimation of emissions in Transport sector are carried out in the sub-categories listed below:

- Domestic Aviation (1.A.3.a)
- Road Transportation (1.A.3.b)
- Railways (1.A.3.c)
- Domestic water-borne Navigation (1.A.3.d)
- Pipeline (other transportation) (1.A.3.e.i)

Emissions from this category were 241.3% higher in 2022 than in 1990, and on average emissions increased by more than 7.5% annually.

In 2022, transport sector contributed to 91.87 Mt CO_2 eq. emissions (Figure 3.13). GHG emissions (in CO_2 eq.) from transport sector as a share of total fuel combustion was 23.7% in 2022 while it was 20% in 1990.

GHG emissions by transport sector and transport modes are given in Table 3.37 and 3.38 respectively. As shown in Figure 3.14, road transportation is the major CO_2 source contributing to 94.1% of transport emissions in 2022. Contribution of domestic aviation is 3.7%, domestic water-borne navigation is 1.2%, and railways are 0.6% in 2022. The share of pipeline transportation is 0.5%.

Figure 3.13 GHG emissions for transportation sector, 1990-2022

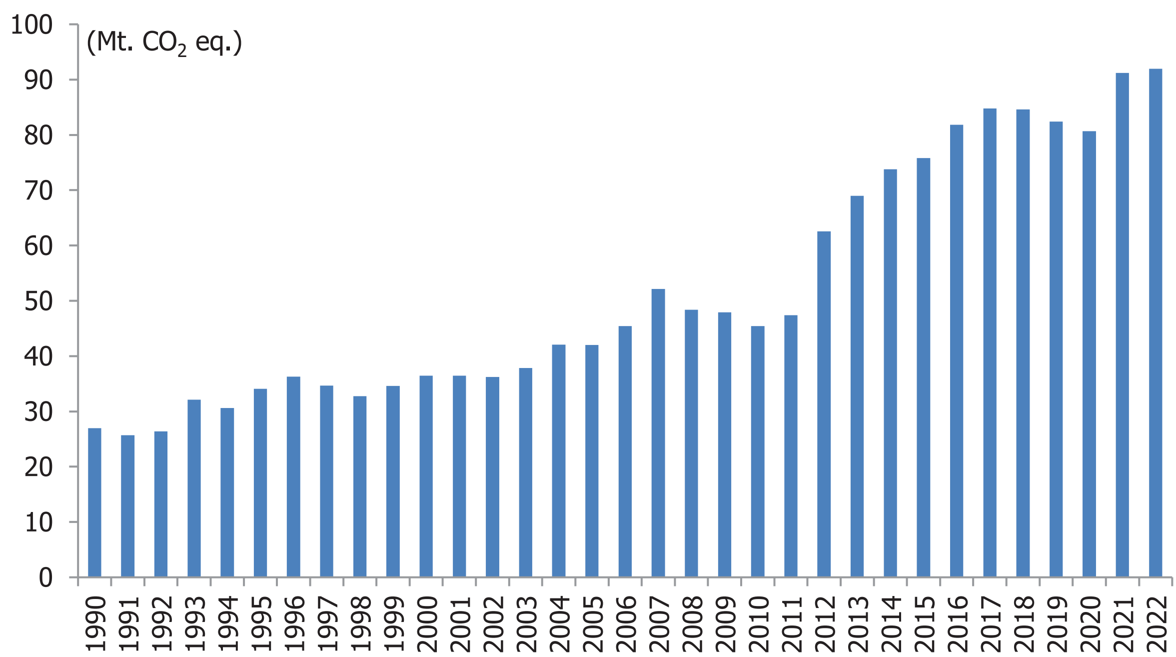


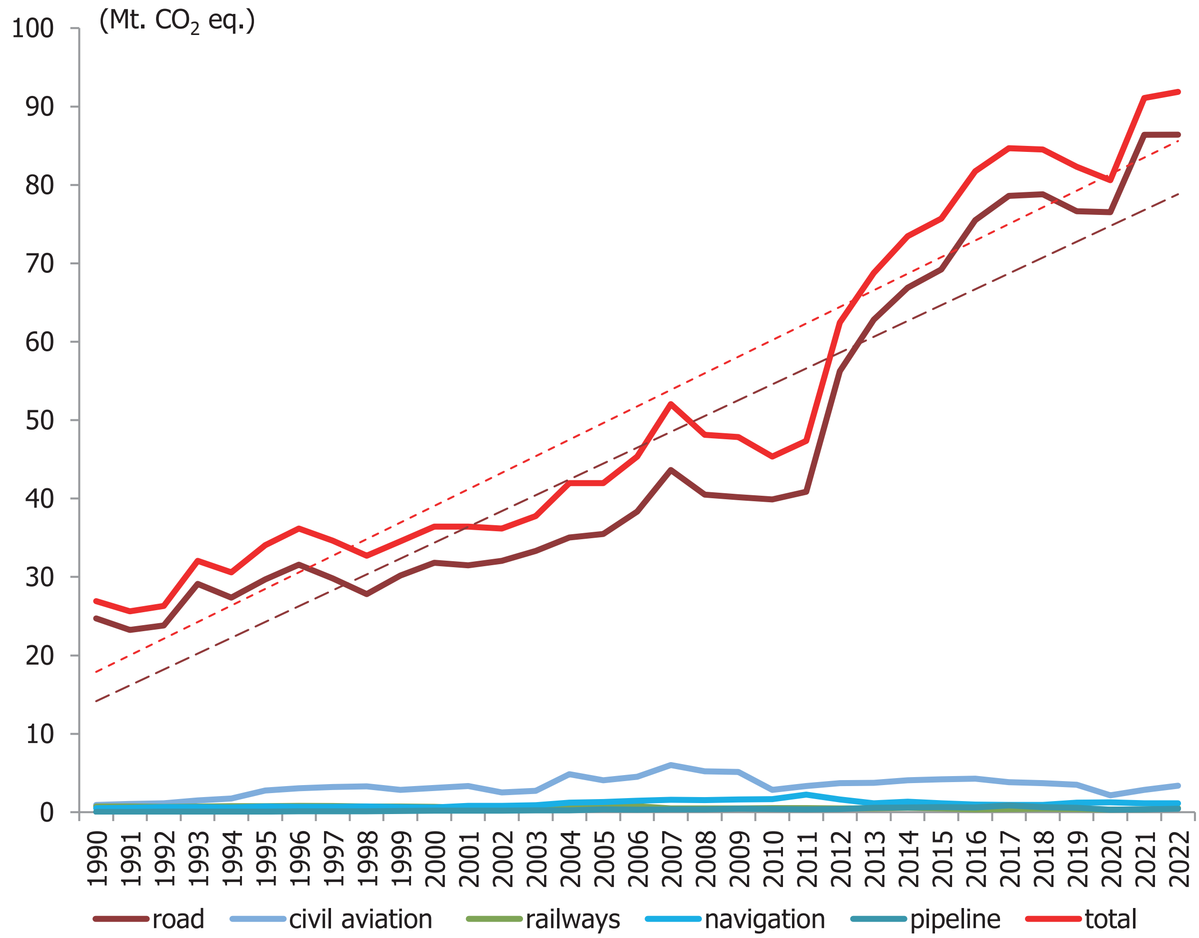
Table 3.37 GHG emissions from transport sector, 1990-2022

Year	CO_2 (kt.)	CH_4 (kt.)	N_2O (kt.)	CO_2 eq. (kt.)	TJ
1990	26 251	4.0	2.1	26 912	364 617
1995	33 180	5.5	2.7	34 041	463 044
2000	35 490	8.9	2.5	36 408	503 352
2005	41 044	8.6	2.6	41 980	578 712
2010	44 383	11.4	2.4	45 346	630 304
2011	46 367	11.5	2.5	47 339	657 982
2012	61 249	12.6	3.2	62 456	862 220
2013	67 478	13.0	3.6	68 787	948 734
2014	72 084	13.6	3.8	73 475	1 013 762
2015	74 263	14.5	3.9	75 713	1 047 749
2016	80 208	15.4	4.2	81 749	1 129 546
2017	82 954	15.4	4.4	84 670	1 182 246
2018	82 788	15.9	4.4	84 518	1 182 683
2019	80 745	16.0	4.3	82 334	1 153 518
2020	79 033	15.2	4.3	80 585	1 124 064
2021	89 319	16.4	4.9	91 087	1 272 385
2022	90 064	16.6	5.1	91 866	1 280 603

Table 3.38 GHG emissions by transport mode, 1990-2022

Year	Road transportation	Domestic aviation	Railways	Domestic navigation	Other transportation	Total
1990	24 729	922	713	508	39	26 912
1995	29 700	2 772	760	726	83	34 041
2000	31 806	3 095	705	623	179	36 407
2005	35 485	4 085	749	1 298	364	41 980
2010	39 904	2 859	511	1 681	390	45 345
2011	40 864	3 340	526	2 240	370	47 339
2012	56 250	3 723	487	1 613	381	62 455
2013	62 820	3 750	499	1 153	563	68 785
2014	66 892	4 086	555	1 347	593	73 473
2015	69 236	4 201	474	1 147	656	75 714
2016	75 511	4 277	370	969	621	81 748
2017	78 615	3 834	408	944	869	84 670
2018	78 818	3 684	430	930	657	84 518
2019	76 635	3 505	396	1 216	581	82 334
2020	76 513	2 162	319	1 263	328	80 585
2021	86 393	2 853	352	1 127	361	91 087
2022	86 408	3 367	505	1 147	439	91 866

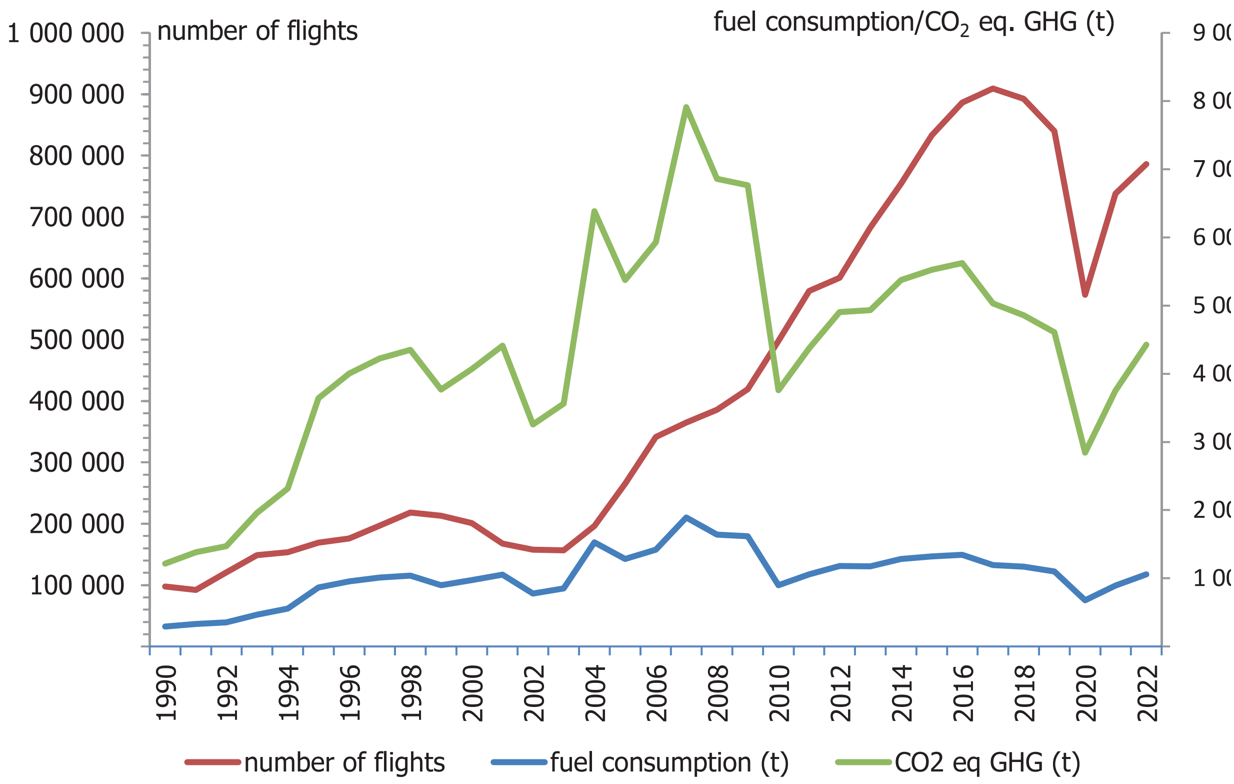
Figure 3.14 GHG emission trend by transport mode, 1990-2022



Throughout the time series, road transportation was the dominant source of emissions in the category, responsible for between 83% (2004) and 92% (1990). The second largest source was domestic aviation, ranging from 3% (1990) and 12% (2007). Between 2004 and 2009, when the share of emissions from road transportation was at their lowest, the share from domestic aviation was the highest.

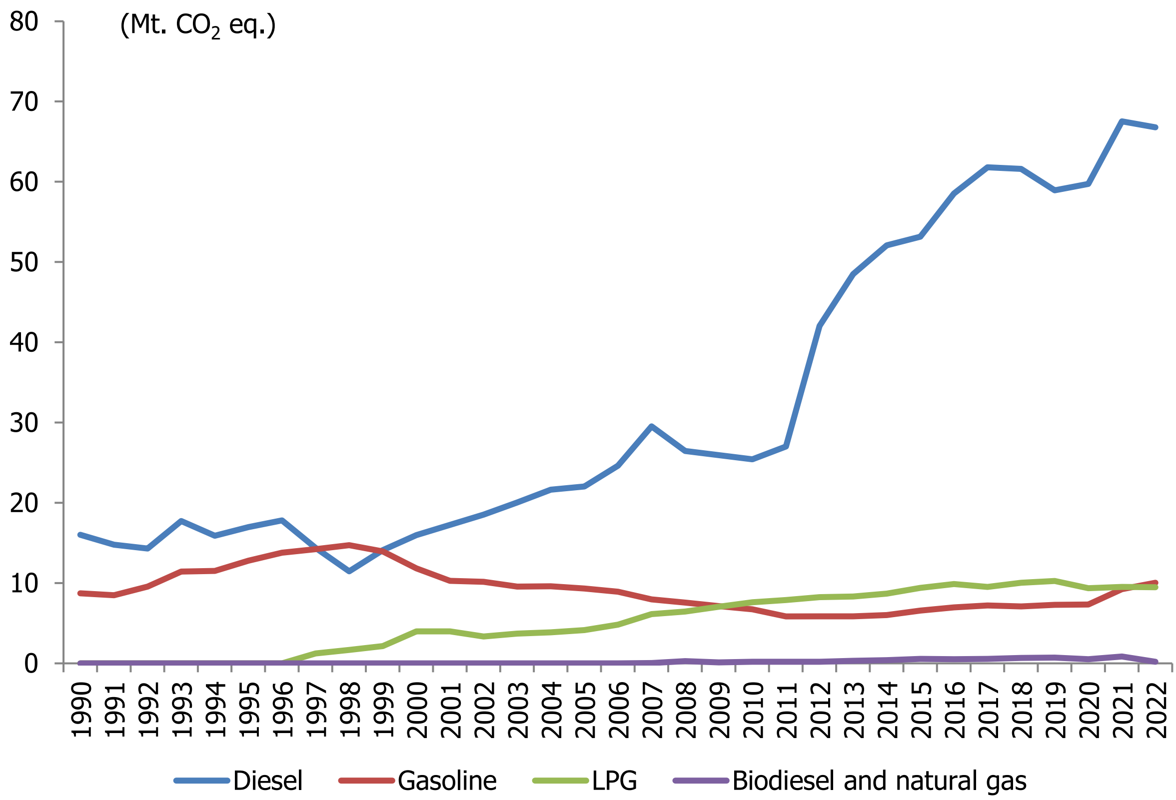
When analyzed in detail (Figure 3.15), there are different factors influencing GHG emissions resulting from domestic aviation. Fuel consumption rose steadily in domestic aviation sector up to year 1999. Because of economic reasons, fuel consumption values declined from 1999 to 2002. However, the rearrangement policy of MoTI resulted in a sudden improvement in civil aviation sector. Then again, the number of flights and fuel consumption started to increase. However, while the number of flights annually increased, fuel consumption and GHG emissions showed inter-annual variation following parallel trends. Especially, from 2007 to 2010 fuel consumption and GHG emissions declined by approximately 50% while the number of flights increased by roughly 35%. This decoupling could partially be explained with renewal of the Turkish air fleet and the global economic crisis, but the main reason of decoupling could be determined with improving data quality in domestic aviation sector. Another breaking point in emissions was in 2019-2020 period. The number of flights and fuel consumption decreased in 2020 due to pandemic conditions. As a result, GHG emissions declined approximately 40% compared to 2019.

Figure 3.15 Comparison of number of flights, fuel consumption and GHG emissions of civil aviation, 1990-2022



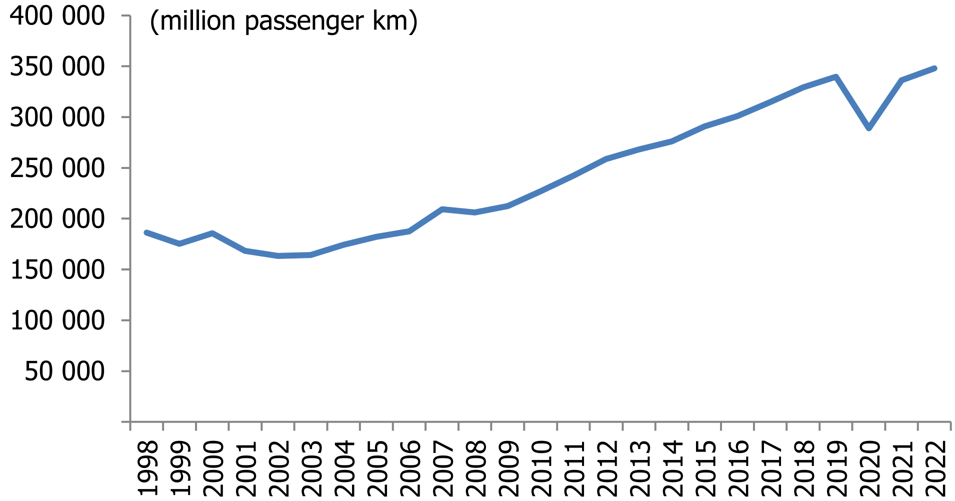
The other transportation mode needed to be analyzed is road transportation (Figure 3.16). In road transportation until the year 1997, only diesel oil and gasoline were used. Utilization of LPG started in 1997 and consumption increased steadily. Then, diesel consumption and LPG consumption increased while gasoline consumption declined. From 2007 to 2010, diesel consumption decreased probably because of the global economic crisis. After that, there is remarkable rise in diesel consumption. When analyzed in detail, it is determined that data of diesel used in agriculture sector have not been separated from those used in road transportation since 2011. That is why there was a large increase in GHG emissions resulting from diesel between 2011 (26 579 kt. CO_2 eq.) and 2022 (65 652 kt. CO_2 eq.), an increase of 150%.

Figure 3.16 Emission distributions by fuel types in road transportation, 1990-2022



As seen from the figure 3.17, million passenger kilometers has been on an increasing trend over the years. Especially, from 2008 onward the increase has been significant year by year. The reason behind this is the number of cars has increased which leads to increase in the number of people traveling by road. This trend reversed due to pandemic conditions in 2020. However, passenger-km by road has recovered in 2021 and almost reached the 2019 values.

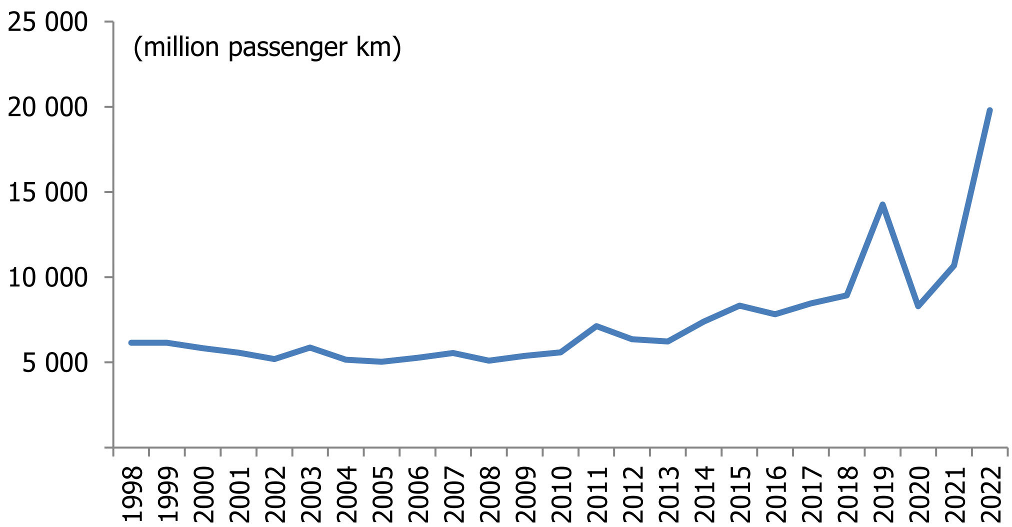
Figure 3.17 Passenger-km by road, 1998-2022 (1)



(1) https://data.oecd.org/transport/passenger-transport.htm

Figure 3.18 represents million passenger kilometers by rail. In recent years, Türkiye has put a lot of emphasis on redeveloping and modernizing the rail infrastructure which has had an effect on the number of passenger kilometers over the years. The modernization of the rail infrastructure requires a temporary stoppage of railway transport until the infrastructure construction is complete. That is the reason of the fluctuation in emissions from 2011 to 2020. But in 2020 the number of passenger kilometers decreased significantly in railway sector which is affected by the covid-19 pandemic. However, passenger-km by railway has started to recover in 2021.

Figure 3.18 Passenger-km by railway, 1998-2022 (2)



(2) https://data.oecd.org/transport/passenger-transport.htm

Source Category Description:

The source category comprises GHG emissions resulting from transport sector as follows; aviation, railways, road transportation, navigation and pipeline transport (other transportation). In addition to these, international aviation and international navigation were also included in this category. Among these categories;

- Domestic aviation in terms of CO_2 emissions from jet fuel (level and trend),
- Road transportation in terms of CO_2 emissions from diesel, LPG, gasoline and other ones (biofuel and natural gas) (level and trend),
- Domestic navigation in terms of CO_2 emissions from diesel and fuel oil,

Emissions from civil aviation were covered as international aviation and domestic aviation under (1.A.3.a.i) and (1.A.3.a.ii) categories.

Road transportation is the largest contributor to transport emissions and estimations were made under a wide variety of vehicle types using not only gasoline but also diesel fuel and LPG. It is covered under category (1.A.3.b).

Emissions from railways were reported under category (1.A.3.c).

Emission estimates from the navigation section cover international water-borne navigation (1.A.3.d.i) and domestic navigation-coastal shipping (1.A.3.d.ii).

Pipeline transportation emissions are reported under the category other transportation (1.A.3.e.i).

Methodological Issues:

Türkiye implements Tier 1 and Tier 2 methodologies to estimate GHG emissions of mobile sources for the time series 1990-2019, as shown in equation below. The general method is presented here, and any specific circumstances in the implementation of the method is described separately for each category.

$$Emissions = \sum_{a} [Fuel_a * EF_a]$$

Where:
Emission = Emissions of CO_2 (kg)
$Fuel_a$ = fuel sold (TJ)
EF_a = emission factor (kg/TJ). This is equal to the carbon content of the fuel multiplied by 44/12.

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

All EFs were taken from the 2006 IPCC Guidelines.

The IPCC methods used in transport sector calculations are listed in Table 3.39.

Table 3.39 Method used in the calculation of GHG emissions by transport modes

Modes of transport	CO_2	CH_4	N_2O	Tier I	Tier II
Domestic aviation	√	√	√	X	X
Road transportation	√	√	√	X	X
Railways	√	√	√	X	X
Domestic navigation	√	√	√	X	X
Pipeline transportation	√	√	√	X	X

For the transport source category (1.A.3), the following data sources were used to estimate and calculate emissions:

- Fuel consumption values for source categories (1.A.3.a.i), (1.A.3.a.ii), (1.A.3.b), (1.A.3.c), (1.A.3.d.i), (1.A.3.d.ii) and (1.A.3.e.i) were provided by MENR in the form of the national energy balance tables, MAPEG and Petroleum Pipeline Corporation.
- Air traffic data is provided by Directorate of General (DG) of State Airports Authority for National Aviation (1.A.3.a.ii). Emissions were estimated by using IPCC T2 methodology explained in IPCC Guidelines for National GHG Inventories (IPCC, 2006). The calculation methodology is based on the national energy consumption data and air traffic data for each airport in terms of aircraft type. For the activities, default EFs were used. Air traffic data which consists of landing and take-off (LTO) cycles and cruise is processed for all 55 airports in Türkiye. All activities below 914 m were included in LTO cycle; movements over 914 m altitude were covered in the cruise phase. Domestic flights for all aircraft types have been accounted considering estimated individual fuel consumption values. The necessary EFs for LTO and cruise for each type of aircraft have been chosen from IPCC reference manual.
- The emissions from road transportation were calculated by using IPCC Tier 1&2 methodology. Other values for database improvement were provided from DG of Highways, DG of Turkish State Railways and DG of Civil Aviation.

Source-Specific QA/QC and Verification:

The IPCC Good Practice Guidance is used for the QA/QC procedures of National GHG Emission Inventory. For the quality control purposes, GHG emissions, estimated by using T2 approach, were compared with emissions estimated by using T1 approach. If the difference between the emission values obtained by both methods is less than 5%, calculations were considered to be appropriate.

3.2.6.1. Civil aviation (Category 1.A.3.a)

The domestic aviation source category was a key category in 2022, in terms of both the level and trend analysis of CO_2 emissions from the jet fuel.

Figure 3.19 and Figure 3.20 illustrate the total emissions and the emissions of CH_4 and N_2O increasing trends as CO_2 eq. CO_2 eq. emissions have increased approximately 265% since 1990 and reached to 3.37 Mt CO_2 in 2022. The calculated amounts of CH_4 and N_2O emissions were 1.51 kt. CO_2 eq. and 30.51 kt. CO_2 eq. in 2022 respectively.

Figure 3.19 GHG emissions for domestic aviation, 1990-2022

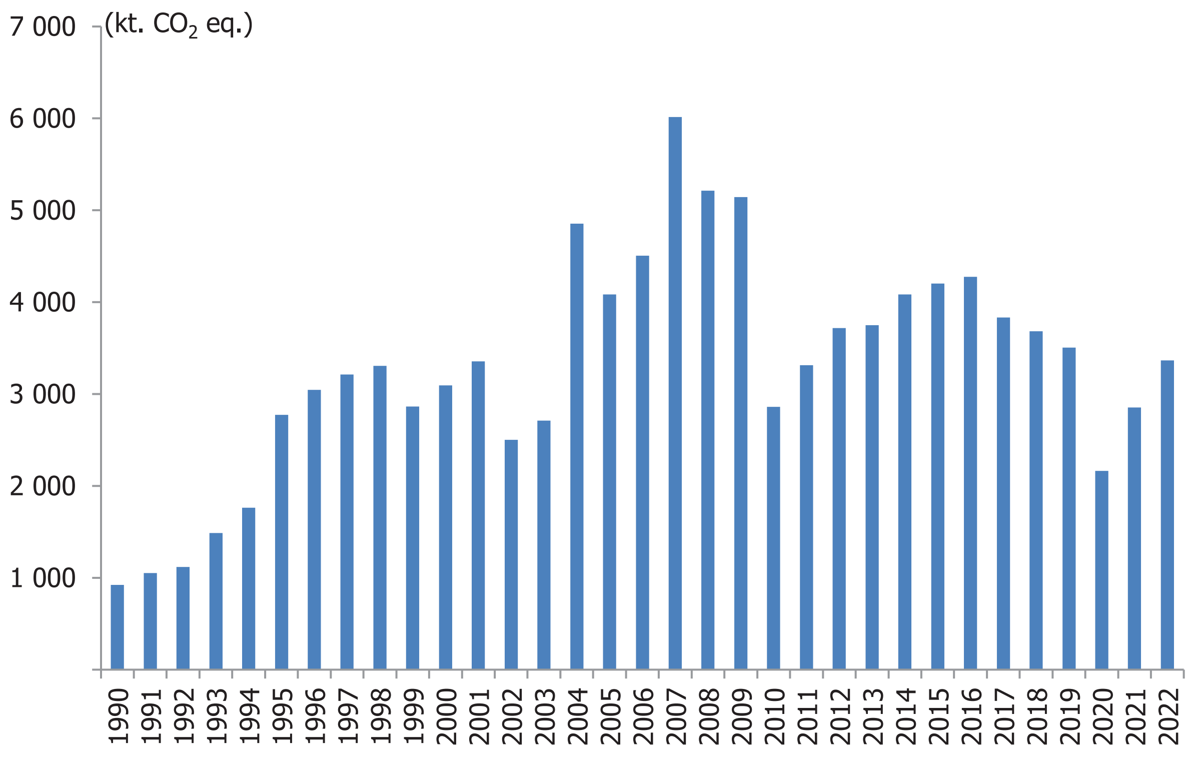
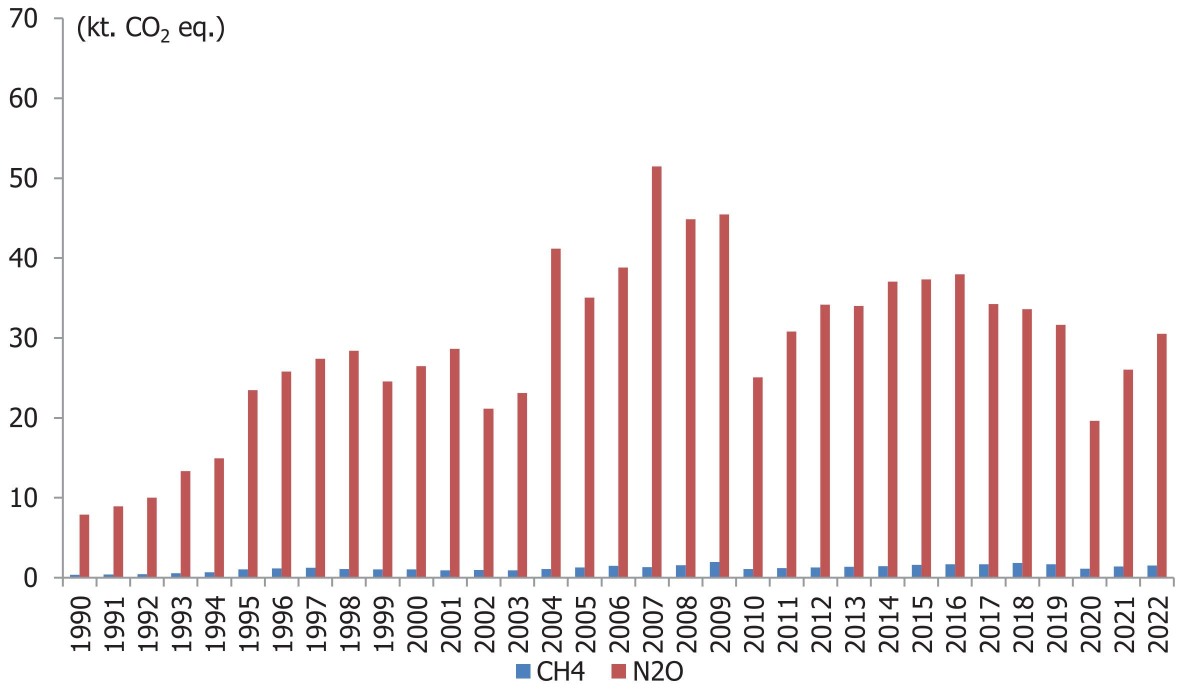


Figure 3.20 CH_4 and N_2O emissions for domestic aviation, 1990-2022



Methodological issues:

Emissions were estimated by using the IPCC T2 methodology explained in the 2006 IPCC Guidelines. In the Tier 2 method, it is necessary to divide the operations of aircraft into landing and take-off (LTO) and cruise phases, as implemented through equations below. The calculation methodology is based on the national energy consumption data and air traffic data for each airport in terms of aircraft type.

$$Total\ emissions = LTOemissions + cruiseemissions$$

$$LTOemissions = NumberofLTOs * EF_{LTO}$$

$$LTOfuelconsumption = NumberofLTOs * FuelconsumptionperLTO$$

$$Cruiseemissions = (TotalFuelConsumption - LTOFuelConsumption) * EF_{Cruise}$$

Collection of activity data:

Air traffic data which consists of LTO cycles and cruise is provided by Directorate of General of State Airports Authority for all civil airports in Türkiye. The number of LTO values for all aircraft types were provided for each airport. All activities below 914 m were included as LTO cycles; movements over

914 m altitude were covered in the cruise phase. Domestic flights for all aircraft types have been accounted considering estimated individual fuel consumption values in the year 2022 total number of LTO's in domestic travel for all aircraft types is 786 150. Passenger and freight traffic from 2006 to 2022 is also given in Figure 3.21 and Figure 3.22 respectively. Figure 3.23 shows the number of domestic LTOs for Turkish airports from 1990 to 2022.

Figure 3.21 Passenger traffic, 2006-2022

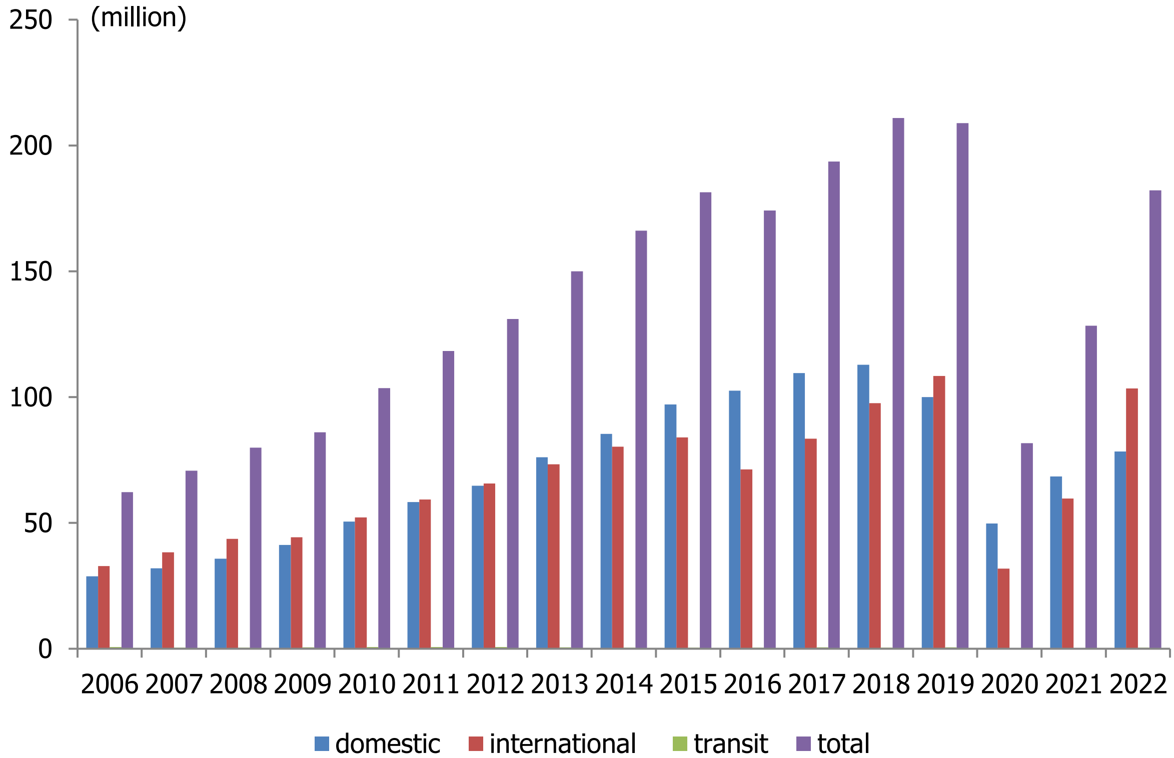
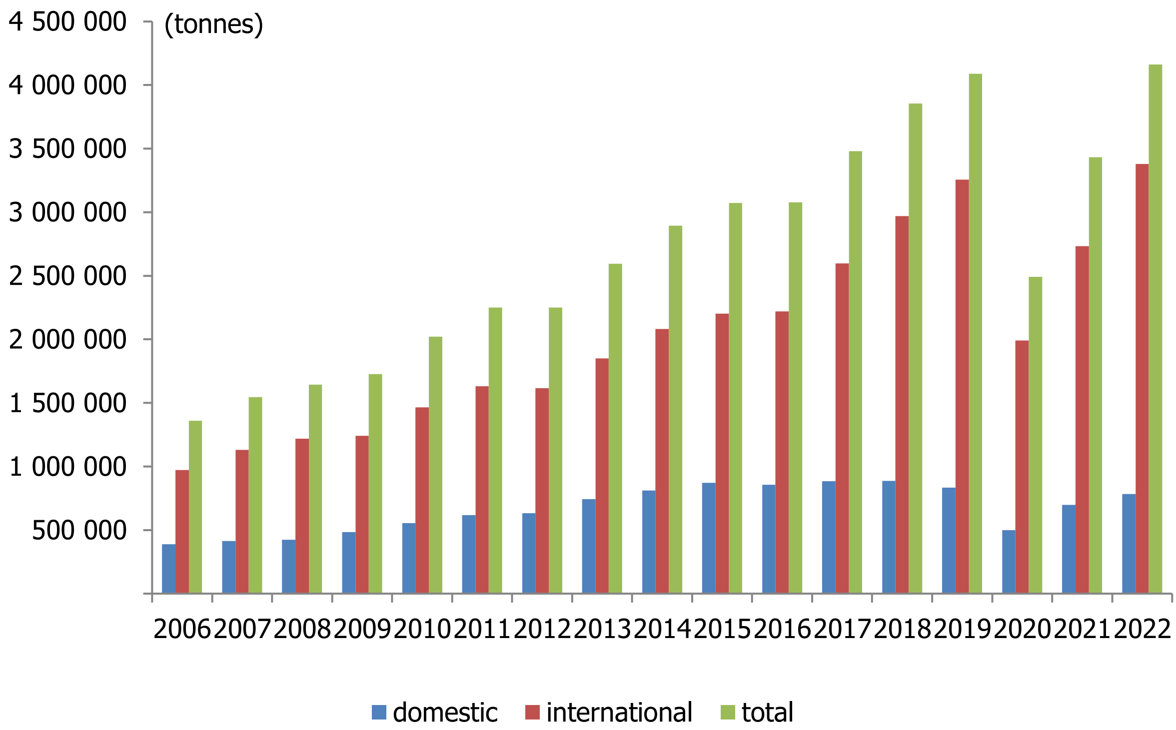
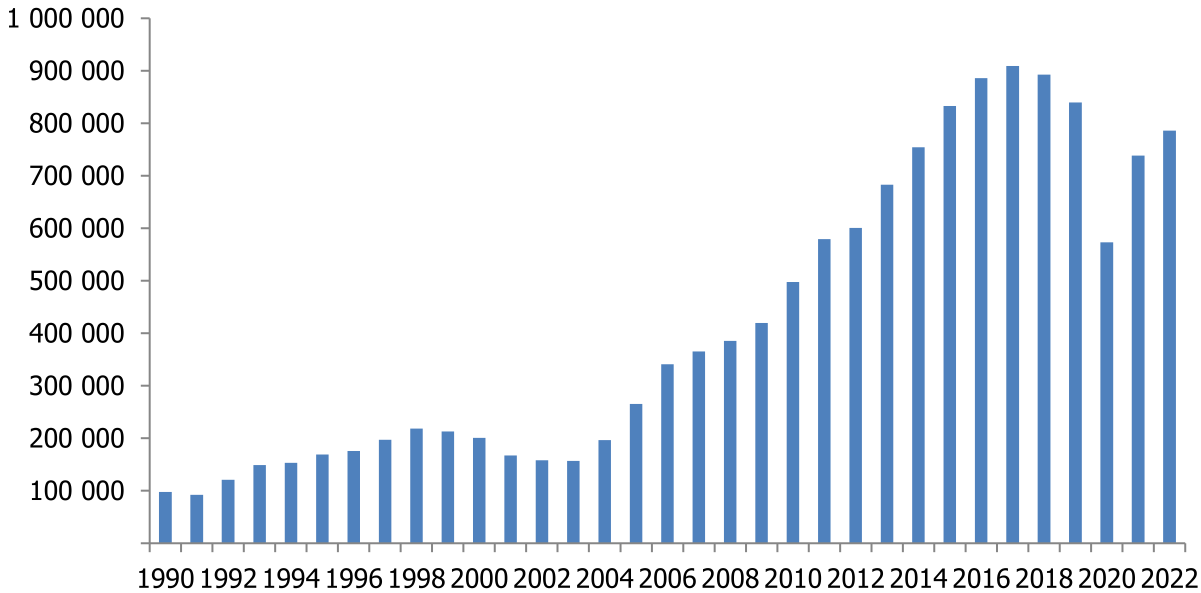


Figure 3.22 Freight traffic, 2006-2022



EFs for all aircraft types were obtained from 2006 IPCC Guidelines for National GHG Inventories (2006 IPCC Guidelines). Default values were applied for aircrafts where specific data is not available. In the light of these explanations, the total fuel consumption for domestic aviation is 1057 kt. To calculate the LTO fuel consumption, Türkiye multiplied the number of LTOs by the relevant LTO fuel consumption factors. The calculated total LTO fuel consumption is 533.5 kt. To estimate cruise fuel consumption, Türkiye subtracts LTO fuel consumption from total fuel consumption for each year of the time series. In 2022, cruise fuel consumption is 523.6 kt.

Figure 3.23 Number of domestic LTO, 1990-2022



Choice of Emission Factor:

LTO fuel consumption factors, as well as default CO_2, CH_4 and N_2O emission factors for all aircraft types were obtained from the 2006 IPCC Guidelines (Table 3.6.9). Default emission factor values were applied for aircrafts where specific data are not available. The resulting CO_2 emission values of 1.69 Mt and 1.65 Mt were reported for LTO and cruise respectively. CO_2, CH_4 and N_2O emission values are given in Table 3.40.

Table 3.40 GHG emissions from domestic aviation, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	914	0.01	0.03	923	13 030
1995	2 748	0.04	0.09	2 775	38 670
2000	3 068	0.04	0.10	3 099	43 296
2005	4 048	0.05	0.13	4 089	57 276
2010	2 833	0.04	0.09	2 862	40 043
2011	3 308	0.04	0.12	3 344	47 199
2012	3 688	0.05	0.13	3 727	52 686
2013	3 715	0.05	0.13	3 754	52 467
2014	4 047	0.05	0.14	4 090	57 243
2015	4 162	0.06	0.14	4 205	58 824
2016	4 237	0.06	0.14	4 281	59 884
2017	3 798	0.06	0.13	3 838	53 259
2018	3 648	0.07	0.13	3 688	52 217
2019	3 472	0.06	0.12	3 509	49 140
2020	2 141	0.04	0.07	2 164	30 233
2021	2 825	0.05	0.098	2 856	39 926
2022	3 335	0.05	0.115	3 367	47 140

Table 3.41 GHG emissions for LTO and cruise in domestic aviation, 2022

(kt.)

	CO_2	CH_4	N_2O	Jet kerosene
Total	3 335	0.05	0.115	1 057
LTO	1 685	0.05	0.062	533.5
Cruise	1 650	-	0.053	523.6

Table 3.42 IEFs of domestic aviation 1990-2022

	Activity	IEFs		
		CO_2	CH_4	N_2O
Year	**TJ**	**t/TJ**	**kg/TJ**	**kg/TJ**
1990	13 030	70.13	0.96	2.29
1995	38 670	71.06	0.95	2.29
2000	43 296	70.86	0.86	2.31
2005	57 276	70.68	0.80	2.31
2010	40 043	70.75	0.95	2.36
2011	47 199	70.09	0.92	2.46
2012	52 686	69.99	0.88	2.45
2013	52 467	70.81	0.92	2.45
2014	57 243	70.70	0.90	2.44
2015	58 824	70.75	0.98	2.39
2016	59 884	70.75	0.99	2.39
2017	53 259	71.32	1.12	2.43
2018	52 217	69.86	1.27	2.43
2019	49 140	70.66	1.22	2.43
2020	30 233	70.81	1.31	2.45
2021	39 926	70.78	1.26	2.46
2022	47 140	70.74	1.14	2.44

Uncertainties and Time-Series Consistency:

The AD was taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 5.48% liquid fuels.

EF uncertainty for CO_2 was considered as 5% as indicated in 2006 IPCC Guidelines Vol. 2 page 3.69. For CH_4 and N_2O mid value of default uncertainty given in 2006 IPCC Guidelines as 80% and 85% were considered respectively.

Recalculation:

There is no recalculation for this category.

Planned Improvement:

There is no planned improvement for this sector.

3.2.6.2. Road transportation (Category 1.A.3.b)

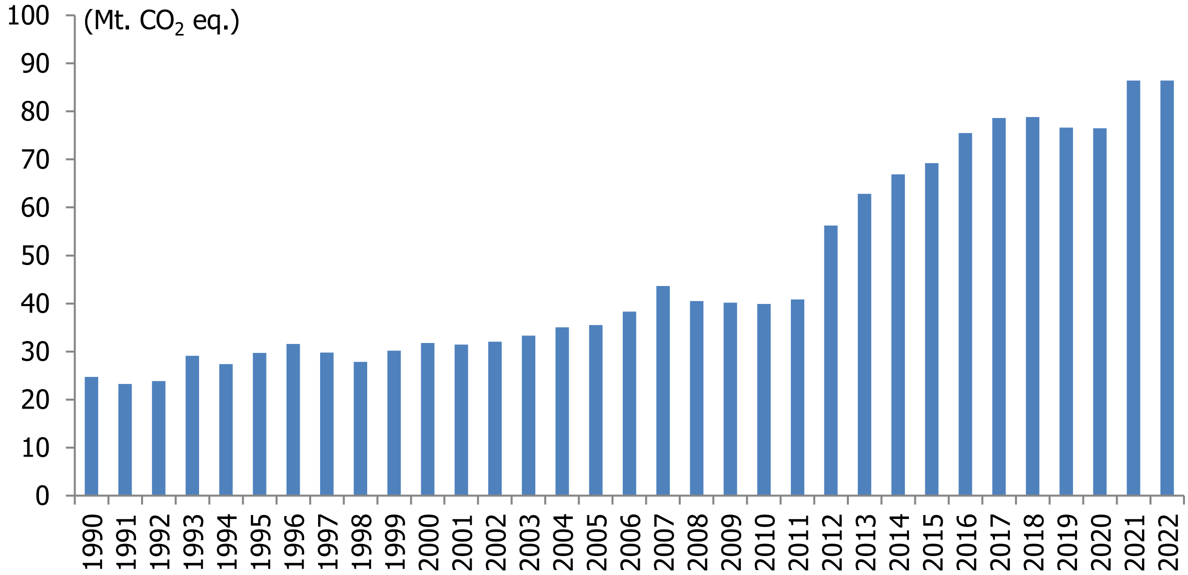
Road Transportation source category was a key category, in terms of emission level of CO_2 from diesel, LPG and gasoline in 2022. This category was also a key category in terms of emission trend of CO_2 from LPG, gasoline and diesel. The results according to IPCC Tier 1&2 were in Table 3.43.

Table 3.43 GHG emissions from road transportation, 1990-2022

Year	CO_2 (kt.)	CH_4 (kt.)	N_2O (kt.)	CO_2 eq. (kt.)	TJ
1990	24 143	3.9	1.804	24 729	335 589
1995	28 942	5.3	2.301	29 700	404 093
2000	30 988	8.8	2.158	31 806	439 986
2005	34 668	8.4	2.195	35 485	488 494
2010	39 033	11.2	2.106	39 906	554 362
2011	39 995	11.2	2.093	40 863	567 688
2012	55 142	12.4	2.882	56 252	775 067
2013	61 607	12.8	3.224	62 821	864 602
2014	65 608	13.4	3.434	66 894	921 018
2015	67 889	14.3	3.561	69 235	955 968
2016	74 055	15.2	3.887	75 512	1 041 071
2017	77 094	15.2	4.132	78 615	1 095 446
2018	77 289	15.7	4.116	78 818	1 100 570
2019	75 131	15.8	4.005	76 635	1 072 046
2020	75 024	15.0	4.035	76 513	1 066 461
2021	84 699	16.2	4.680	86 393	1 206 164
2022	84 698	16.4	4.719	86 408	1 203 618

In road transportation, gasoline, diesel, LPG, natural gas and biodiesel were used as fuel. Road transportation being the major source within the transportation sector contributed 86.4 Mt of CO_2 eq. in 2022 (Figure 3.24). Emissions of CH_4 reached 0.46 Mt CO_2 eq. and N_2O reached 1.25 Mt CO_2 eq. in 2022 (Figure 3.25). Emissions from the consumption of biofuels were taken into consideration for CH_4 and N_2O emissions.

Figure 3.24 GHG emissions for road transportation, 1990-2022



CO_2 emissions according to fuel types are illustrated in Figure 3.26. Most important portion of CO_2 emission is occurred from diesel fuel consumption, which is about 78% of total emissions of road transportation.

Figure 3.25 CH_4 and N_2O emissions for road transportation, 1990-2022

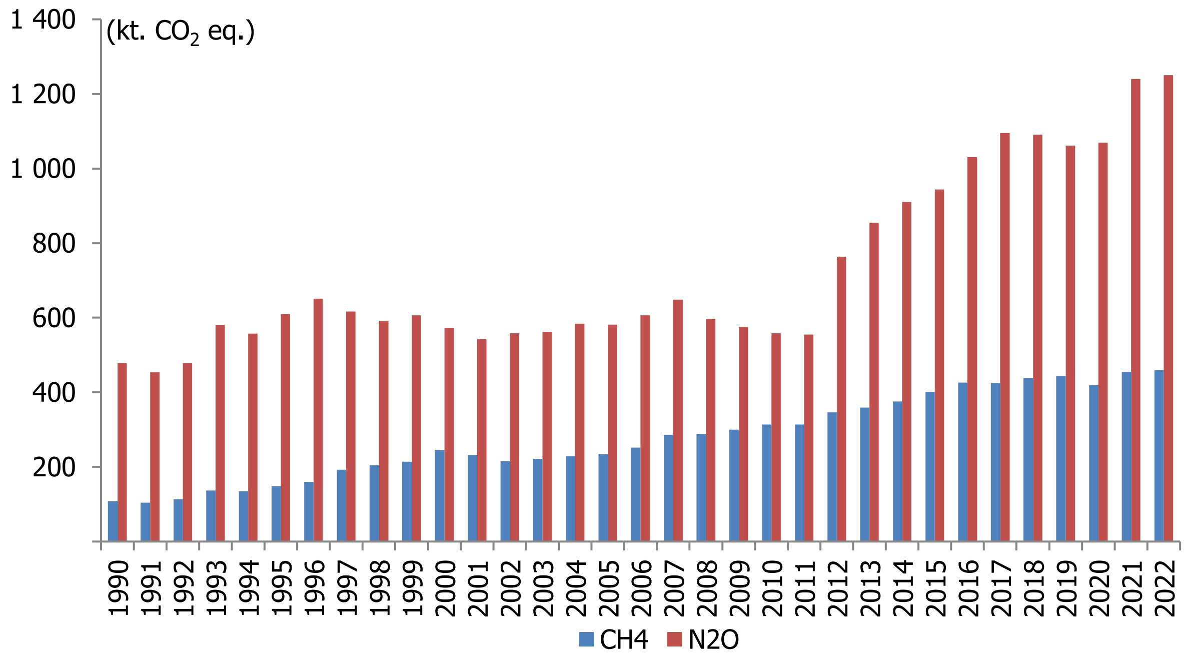
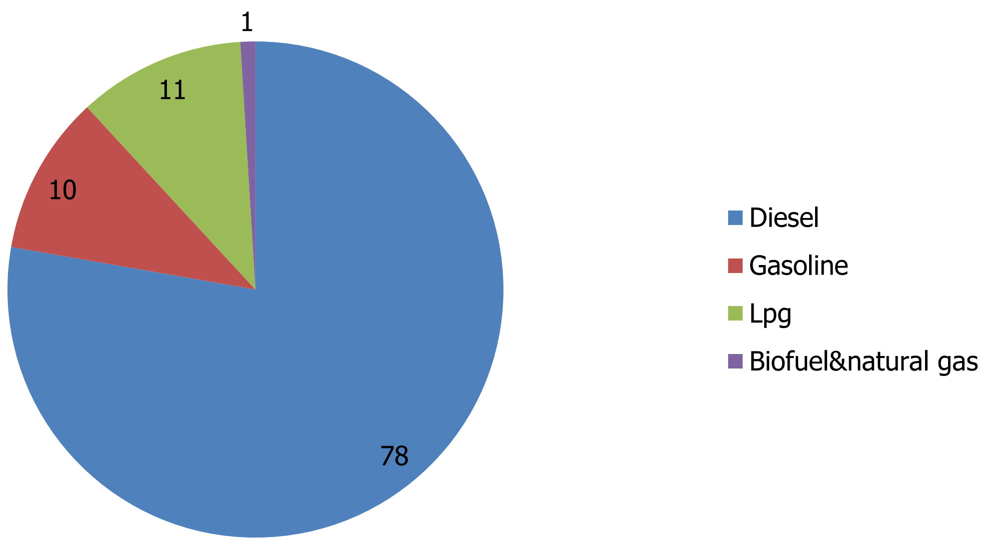


Figure 3.26 CO_2 emission distributions by fuel types (%), 2022



Methodological issues:

CO_2 emissions were calculated by multiplying estimated fuel consumption by a default or country-specific, depending on the fuel emission factor i.e., a Tier 1 or Tier 2 method. Country-specific carbon contents for diesel and natural gas are used. CO_2 emissions resulting from those fuel types were estimated with Tier 2. CO_2 resulting from gasoline, LPG and CH_4 and N_2O emissions were estimated by applying default emission factors from the 2006 IPCC Guidelines.

Collection of Activity Data:

Fuel data used in the road transportation are taken from the national energy balance tables issued by MENR.

Choice of Emission Factor:

To estimate CO_2 emissions, Türkiye applies the country specific (diesel, natural gas) and default carbon contents as contained in the 2006 IPCC Guidelines.

Source-Specific QA/QC and Verification:

Fuel consumption data in road transportation provided by the MENR were compared with those of DG of Mining and Petroleum Affairs, reported to IEA.

To verify data documentation, the assumptions and selection criteria on data, EFs and other calculation parameters as well as the completeness of inventory dossiers were checked for correspondence with the 2006 IPCC Guidelines.

In addition, GHG emissions from road transportation were also calculated by using COPERT V program for the years 2016, 2017 and 2018. COPERT V results were compared with the results regarding current methodology (Tier 1, Tier 2) and in terms of CH_4, COPERT result was found by far less than results obtained by using current methodology due to usage of default emission factors. Moreover, results obtained from COPERT V were also compared with CRT values of several countries (e.g., Denmark, United Kingdom, Greece, Italy) using COPERT methodology. Considered comparison of implied emission factors, values were found almost in line with each other.

Table 3.44 Comparison of COPERT and current methodology for GHG emissions from road transportation, 2016-2018

	CO_2 (kt)		CH_4 (kt)		N_2O (kt)		CO_2 eq. (kt)	
Year	**Tier 2**	**COPERT**	**Tier 1**	**COPERT**	**Tier 1**	**COPERT**	**Tier 1&2**	**COPERT**
2016	74 055	74 663	15.2	4.952	3.9	2.637	75 595	75 573
2017	77 094	78 701	15.2	5.677	4.1	2.807	78 706	79 679
2018	77 289	79 015	15.7	5.230	4.1	2.866	78 907	80 000

With this calculation results obtained from COPERT for the years 2016-2018.

Uncertainties and Time-Series Consistency:

The AD was taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 10.05% for liquid fuels.

EF uncertainty for CO_2 was considered as 5% (max. value of given range) as indicated in 2006 IPCC Guidelines Vol. 2 page 3.29. For CH_4 and N_2O mid value of default uncertainty given in 2006 IPCC Guidelines as 250% were considered.

Recalculations:

There is no recalculation for this category.

Planned Improvement:

There is no planned improvement for this sector.

3.2.6.3. Railways (Category 1.A.3.c)

The railways source category was not a key category in 2022. Figure 3.27 and Figure 3.28 show the total, CH_4 and N_2O emissions as CO_2 eq. respectively. CO_2 eq. emissions have declined 29.2% since 1990. The emissions calculated for railways is 0.505 Mt CO2 eq. in 2022.

Table 3.45 GHG emissions from railway, 1990-2022

Year	CO_2	CH_4	N_2O	CO_2 eq.	TJ
1990	651	0.03	0.23	713	8 670
1995	688	0.04	0.27	760	9 348
2000	638	0.04	0.25	705	8 686
2005	678	0.04	0.26	749	9 230
2010	462	0.03	0.18	511	6 296
2011	476	0.03	0.19	526	6 485
2012	441	0.02	0.17	487	6 001
2013	452	0.03	0.18	499	6 154
2014	503	0.03	0.20	555	6 843
2015	429	0.02	0.17	474	5 848
2016	335	0.02	0.13	370	4 561
2017	369	0.02	0.15	408	5 105
2018	388	0.02	0.15	430	5 373
2019	358	0.02	0.14	396	4 946
2020	289	0.02	0.11	319	3 995
2021	318	0.02	0.13	352	4 404
2022	457	0.03	0.18	505	6 319

Figure 3.27 GHG emissions for railways, 1990-2022

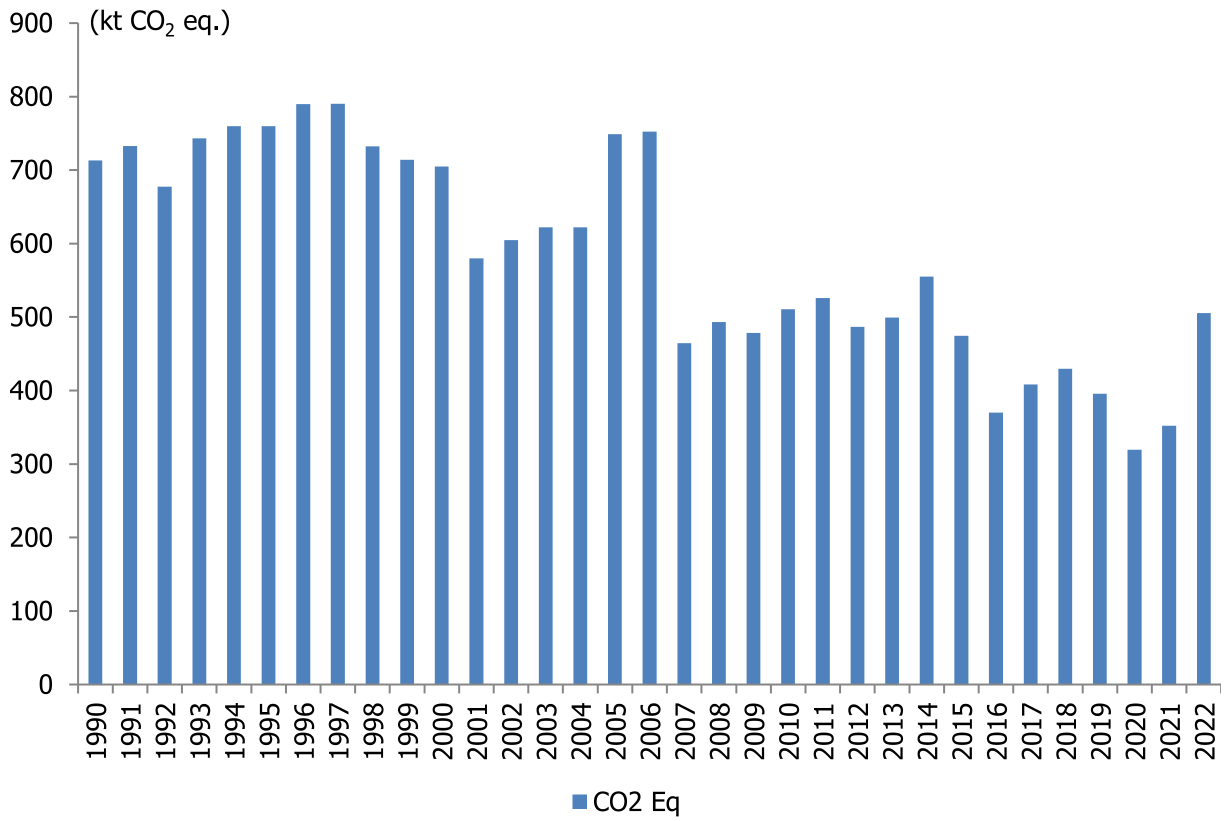
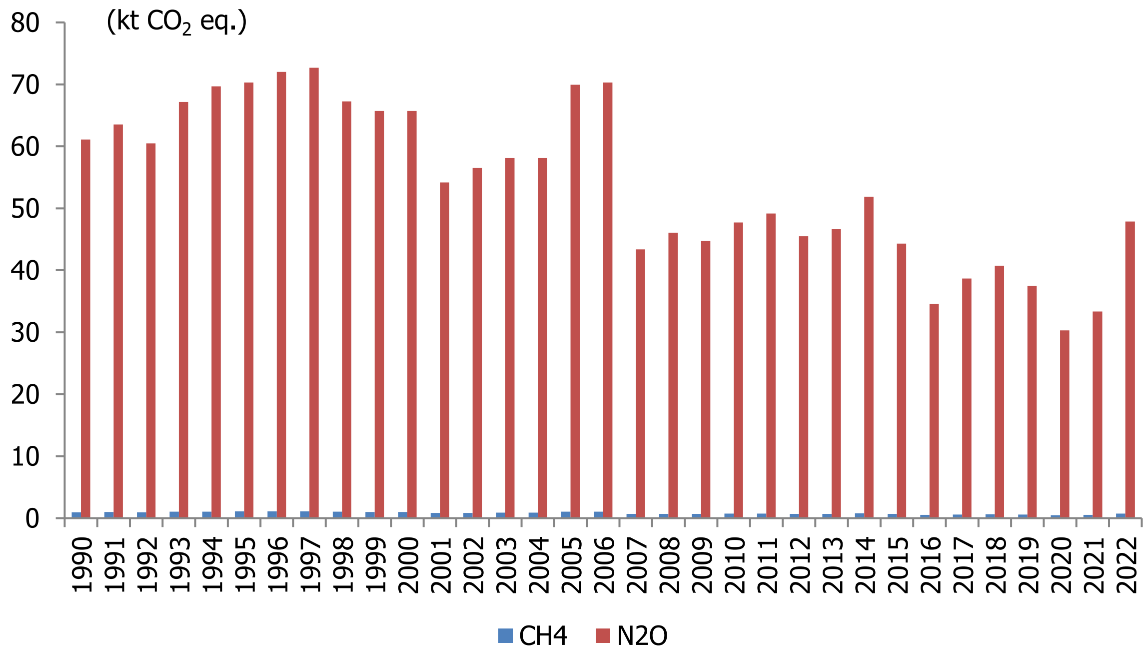


Figure 3.28 CH_4 and N_2O emissions from railways, 1990-2022



Methodological issues:

The IPCC Tier 1&2 approach has been used to estimate CO_2, CH_4 and N_2O emissions for this subcategory. The Tier 1 approach has been used to estimate CH_4 and N_2O emissions.

Collection of Activity Data:

Energy consumption values for railways were provided by MENR in the form of national energy balance tables.

Choice of Emission Factor:

To estimate CO_2 emissions, Türkiye applies the country specific carbon content. Türkiye does not modify the emission factors for CH_4 and N_2O to consider engine design parameters.

Source-Specific QA/QC and Verification:

In terms of calculations made by alternative methods; verification on this category was made by using different AD (passenger/km) and different EFs provided in the document "Structure of Costs and Charges Review – Environmental Costs of Rail Transport Final Report to the Office of Rail Regulation (August 2005)". As a result of the verification, it was observed that the results obtained were almost identical in each calculation methodology. In addition, fuel consumption values obtained from Energy Balance Table were compared with those reported to IEA.

Uncertainties and Time-Series Consistency:

The AD was taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 2% for liquid fuels.

EF uncertainty for CO_2 was derived from 2006 IPCC Guidelines Vol. 2 table 3.4.1 as 1.5% for liquid fuels. For CH_4, EF uncertainties were derived as 105% for liquid fuels. For N_2O EFs uncertainties were derived as 142% for liquid fuels.

Recalculations:

There is no recalculation for this category.

Planned Improvement:

There is no planned improvement for this category.

3.2.6.4. Water-borne navigation (Category 1.A.3.d)

The domestic water borne navigation source category was not a key category in 2022. The data availability is limited in this sub-sector. In domestic water-borne navigation diesel and residual fuel oil were consumed as a fuel.

Domestic water-borne navigation contributed 1.15 Mt of CO_2 in 2022. While CH_4 3.07 kt. CO_2 eq. and N_2O emissions were 8.30 kt. CO_2 eq. (Figure 3.29 and 3.30). Overall, between 1990 and 2022 emissions from water-borne navigation increased by 125.6%.

Table 3.46 GHG emissions from domestic navigation, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	504	0.05	0.01	508	6 624
1995	719	0.07	0.02	726	9 444
2000	617	0.06	0.02	623	8 167
2005	1 286	0.12	0.03	1298	17 225
2010	1 664	0.16	0.05	1681	22 658
2011	2 218	0.21	0.06	2240	30 058
2012	1 598	0.15	0.04	1613	21 670
2013	1 142	0.11	0.03	1153	15 486
2014	1 334	0.13	0.04	1347	18 083
2015	1 136	0.11	0.03	1147	15 369
2016	960	0.09	0.03	969	12 958
2017	934	0.09	0.03	944	12 836
2018	921	0.09	0.03	930	12 650
2019	1 204	0.12	0.03	1 216	16 563
2020	1 251	0.12	0.03	1 263	17 265
2021	1 116	0.11	0.03	1 127	15 390
2022	1 136	0.11	0.03	1 147	15 658

Figure 3.29 GHG emissions from domestic water-borne navigation, 1990-2022

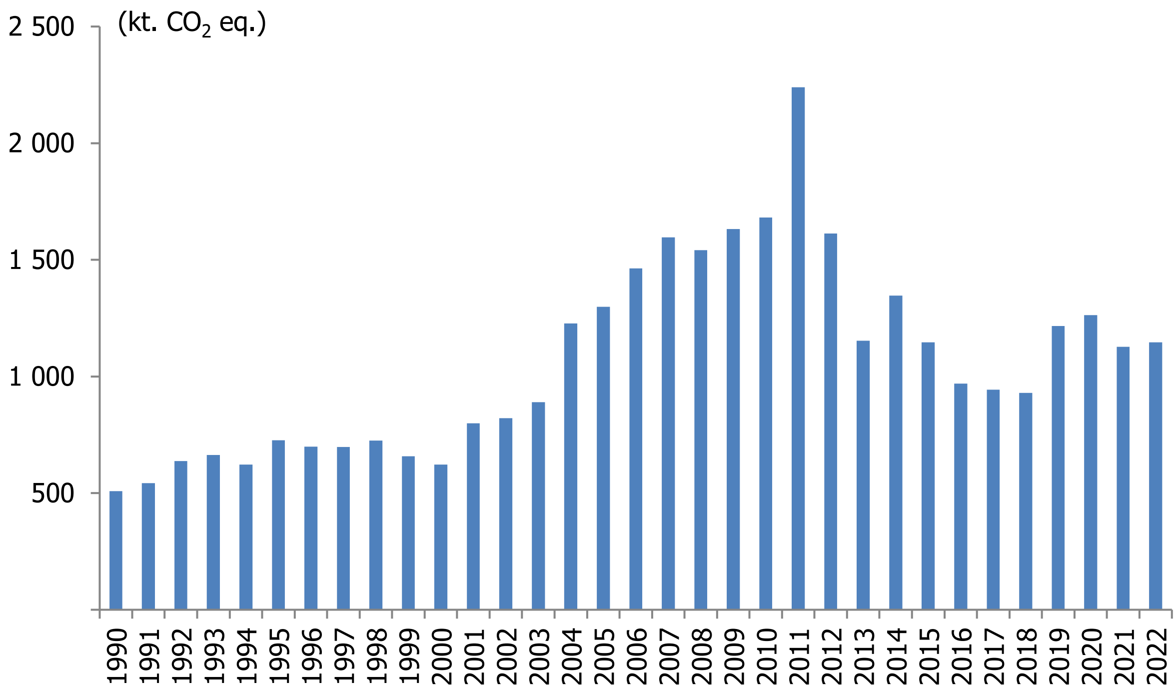
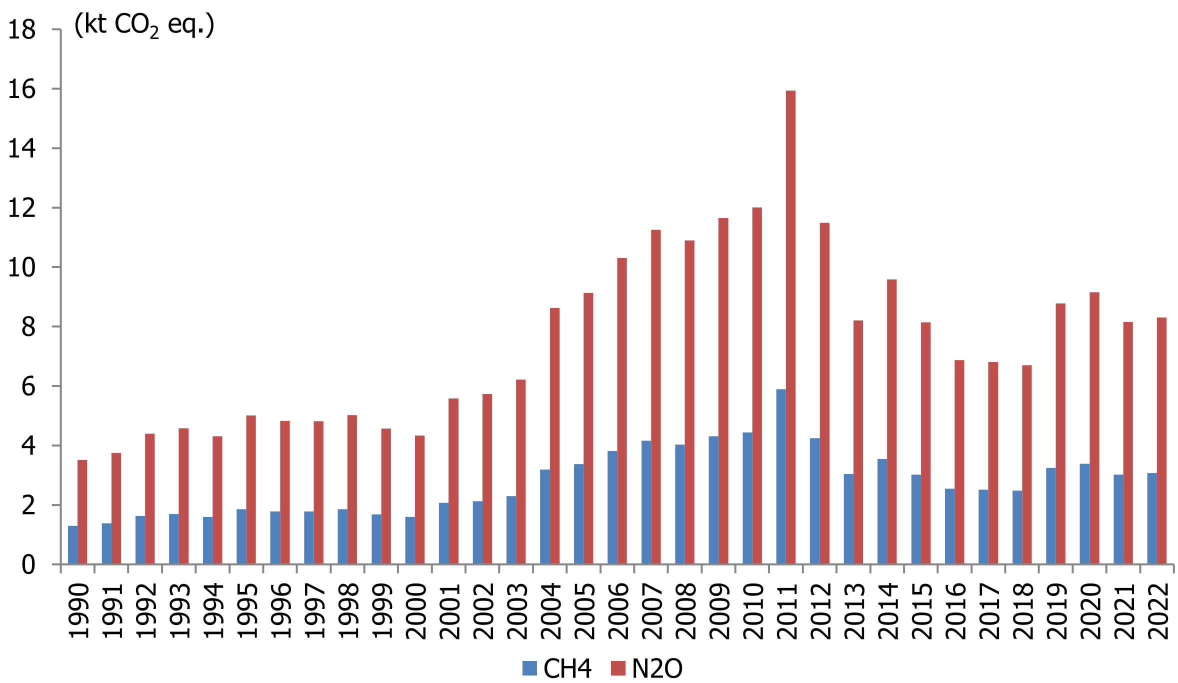


Figure 3.30 CH_4 and N_2O emissions from domestic water-borne navigation, 1990-2022



Methodological issues:

The IPCC Tier 1&2 approach has been used to estimate CO_2, CH_4 and N_2O emissions for this subcategory. The Tier 1 approach has been used to estimate CH_4 and N_2O emissions.

Collection of Activity Data:

Energy consumption values for domestic navigation were provided by MENR in the form of national energy balance tables.

Choice of emission factor:

For CO_2 estimation, country-specific carbon contents were used. The EFs for CH_4 and N_2O are taken from IPCC 2006/CORINAIR and set to 7 and 2 kg per TJ respectively.

Source-Specific QA/QC and Verification:

On the energy balance table provided by the MENR, diesel and fuel oil consumption values were compared with the values provided by MoTI DG of Maritime, as well as the Annual Activity Report results of Energy Market Regulatory Authority and with the "Domestic Navigation" fuel consumption amount values which DG of Mining and Petroleum Affairs regularly reports to the IEA.

Uncertainties and Time-Series Consistency:

The AD was taken from MENR. AD uncertainties were determined as 15% for liquid fuels.

EF uncertainty for CO_2 was considered as 1.5% for liquid fuels as indicated in 2006 IPCC Guidelines Vol. 2 page 3.54. It was considered as 50% for CH_4 and 140% for N_2O.

Recalculations:

There is no recalculation for this category.

Planned Improvement:

There is no planned improvement for this category.

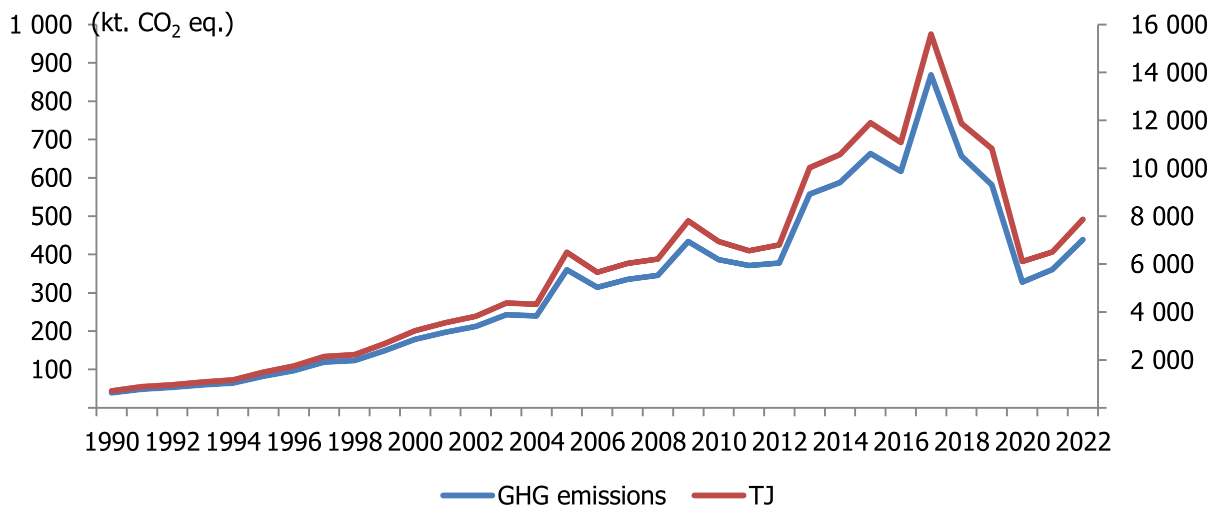
3.2.6.5. Pipeline transport (Category 1.A.3.e.i)

This category covers combustion related emissions from the operation of pump stations and maintenance of pipelines. Transport via pipelines includes transport of gases, liquids, slurry and other commodities via pipelines. In Türkiye, natural gas is used to carry out operations mentioned above. Pipeline transport contributed 0.44 Mt of CO_2 in 2022. Table 3.47 shows the trend in GHG emissions from pipeline transport

Table 3.47 The trend in GHG emissions from pipeline transport, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	39	0.0007	0.00007	39	705
1995	83	0.0015	0.00015	83	1 489
2000	179	0.0032	0.00032	179	3 217
2005	363	0.0065	0.00065	364	6 487
2010	390	0.0069	0.00069	390	6 945
2011	369	0.0066	0.00066	369	6 552
2012	381	0.0068	0.00068	381	6 796
2013	562	0.0100	0.00100	563	10 025
2014	593	0.0106	0.00106	593	10 575
2015	655	0.0117	0.00117	656	11 897
2016	621	0.0111	0.00111	621	11 073
2017	868	0.0156	0.00156	869	15 601
2018	656	0.0119	0.00119	657	11 873
2019	581	0.0108	0.00108	582	10 824
2020	328	0.0061	0.00061	328	6 109
2021	360	0.0065	0.00065	361	6 501
2022	438	0.0079	0.00079	439	7 868

Figure 3.31 GHG emissions from pipeline transport, 1990-2022



Methodological issues:

In emissions calculation, the 2006 IPCC Guidelines Tier 1&2 approaches are used. CO_2 emissions were calculated by multiplying estimated fuel consumption by a country-specific emission factor. CH_4 and N_2O emissions were estimated by applying default emission factors from the 2006 IPCC Guidelines.

Collection of Activity Data:

Fuel consumption data for pipeline transport were provided by energy balance table provided by the MENR.

Choice of emission factor:

For CO_2 estimation, country-specific carbon content was used. In addition, default CH_4 (1 kg/TJ) and N_2O (0.1 kg/TJ) emission factors were obtained from the 2006 IPCC Guidelines.

Source-Specific QA/QC and Verification:

On the energy balance table provided by the MENR, natural gas data were compared with the value provided by Petroleum Pipeline Corporation.

Recalculations:

There is no recalculation for this category.

3.2.6.6. Off road transportation (Category 1.A.3.e.ii)

GHG emissions from off road vehicles used for agricultural activities is included under 1.A.4.c category.

3.2.7. Other sectors (Category 1.A.4)

Source Category Description:

The emissions that are included in this category mainly arise from fuel consumption in commercial/institutional, residential and agriculture/forestry/fisheries. The source category (1.A.4.a) and (1.A.4.b) are considered together since they are not presented separately in the national energy balance tables until 2015. The source category 1.A.4.c includes the emission from the agricultural activities but does not include forestry and fisheries.

The source category 1.A.4 is a key category in terms of emission level and emission trend of CO_2 from solid, liquid and gaseous fuels in 2022. The source category is also a key category in terms of emission trend of CH_4 from solid fuels and biomass.

The share of GHG emissions as CO_2 eq. from other sectors in total fuel combustion was 19% in 2022 while it was 23.7% in1990. It was 19% of total GHG emissions in 2022.

Table 3.48 Fuel combustion emissions from other sectors (1A4), 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in fuel combustion (1A) category (%)
1990	29 277	133	3.7	33 982	646 591	24.7
1995	33 297	126	4.3	37 957	713 541	23.0
2000	33 693	108	4.6	37 936	737 948	17.9
2005	38 826	100	4.7	42 853	771 973	17.8
2010	62 070	152	6.4	68 020	973 007	24.2
2011	69 279	132	7.0	74 820	1010 607	24.8
2012	57 465	138	2.2	61 927	1020 656	19.7
2013	52 999	114	1.8	56 665	1112 130	18.8
2014	52 668	112	2.0	56 350	977 068	17.7
2015	62 558	61	4.0	65 310	1085 732	19.3
2016	62 413	62	4.2	65 247	1152 101	18.6
2017	70 272	73	4.3	73 469	1170 999	19.6
2018	60 102	61	4.1	62 916	1209 191	17.2
2019	66 284	68	4.3	69 331	646 591	19.4
2020	71 915	78	4.6	75 307	713 541	21.0
2021	72 256	71	4.4	75 415	737 948	19.1
2022	72 245	62	4.4	75 142	771 973	19.3

Total GHG emission in 1A4 category decrease 274 kt CO_2 eq. (0.36% of decrease) from 2021 to 2022.

Methodological Issues:

GHG emissions from 1A4 sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EF are used when available, otherwise default CO_2 EF are used. Same CO_2 EFs are used from the summary table 3.8 (from 1.A Fuel combustion sector). All CH_4 and N_2O EF are also default. The default CH_4 and N_2O EF for 1A4 sector are tabulated below.

Table 3.49 N_2O and CH_4 emission factors of fuels used in others sector (1A4).

Sub Sectors	Emission Factors		Source
	CH_4 (kg/TJ)	N_2O(kg/TJ)	
1A4a sub sector			
Coal products	10	1.5	Table 2.4
LPG	5	0.1	Table 2.4
Other petroleum products	10	0.6	Table 2.4
Wood	300	4	Table 2.4
Natural gas	5	0.1	Table 2.4
1A4b, 1A4c sub sectors			
Coal products	300	1.5	Table 2.5
LPG	5	0.1	Table 2.5
Other petroleum products	10	0.6	Table 2.5
Wood	300	4	Table 2.5
Other primary solid biomass	300	4	Table 2.5
Natural gas	5	0.1	Table 2.5

Recalculation:

There is recalculation in N_2O emissions from 1.A.4.A for the years 2015-2020 due to a minor error. It is resulted in changes between 0.02% and 0.11% for these years.

3.2.7.1. Commercial/Institutional (Category 1.A.4.a)

The fuel consumption of commercial/institutional is not separated in the energy balance tables until 2015, it is given under residential sector for 1990-2014 period. Emissions are given under 1.A.4.a category in 2015 for the first time and they are included under (1.A.4.b) for 1990-2014 periods.

The share of GHG emissions as CO_2 eq. from 1.A.4.a in total other sector is 20% in 2022.

Table 3.50 Fuel combustion emissions from 1.A.4.a category, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.4 category (%)
1990	9 632	0.74	0.02	9 659	126 516	28.4
1995	12 984	1.01	0.03	13 021	172 533	34.3
2000	13 163	1.05	0.03	13 201	179 782	34.8
2005	11 904	0.99	0.03	11 940	168 551	27.9
2006	9 463	0.82	0.03	9 493	139 460	22.4
2007	8 985	0.79	0.02	9 014	134 580	19.9
2008	8 810	0.78	0.02	8 838	132 624	13.7
2009	8 539	0.75	0.02	8 567	128 412	12.0
2010	7 027	0.63	0.02	7 050	107 220	10.4
2011	9 015	0.83	0.03	9 045	142 361	12.1
2012	7 194	0.69	0.02	7 219	117 314	11.7
2013	8 653	0.82	0.03	8 682	140 552	15.3
2014	8 395	0.80	0.02	8 424	136 759	14.9
2015	23 281	1.76	0.05	23 344	300 630	35.7
2016	22 004	2.31	0.26	22 137	298 757	33.9
2017	20 540	2.01	0.19	20 647	279 840	28.1
2018	13 484	1.26	0.08	13 540	208 743	21.5
2019	14 620	1.39	0.08	14 680	231 304	21.2
2020	13 581	1.28	0.08	13 638	209 304	18.1
2021	13 895	1.28	0.07	13 950	217 861	18.5
2022	14 988	1.37	0.06	15 043	244 955	20.0

Total GHG emission in 1.A.4.a category increased 1 093 kt CO_2 eq. (8% of increase) from 2021 to 2022.

Methodological Issues:

GHG emissions from 1.A.4.a sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EFs are used for emission estimation. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 7.07% for liquid fuels, 14.14% for solid fuels, and 5% for gaseous fuels.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A4a category was performed on the basis of QA/QC plan. Since only 2015 and 2016 estimation is available for this category, emission trends could not be analyzed.

IEF for CO_2, CH_4, and N_2O are in the range of 2006 IPCC default EFs.

Recalculation:

Emissions from this sector were recalculated due to sub sectoral allocation for the years 1990-2014.

Planned Improvement:

There is no planned improvement

3.2.7.2. Residential (Category 1.A.4.b)

Residential and commercial/institutional fuel consumptions are not separable in the national energy balance tables until 2015. Therefore, emissions from residential and commercial/institutional category are included under 1.A.4.b for periods 1990-2014. After 2015 only residential sector is covered under 1.A.4.b category. Therefore, there is a sharp decrease in 2015 due to the separation of the commercial and institutional category.

The share of GHG emissions as CO_2 eq. from 1.A.4.b category in total other sectors is 65.5% in 2022 while it was 52.8% in 1990.

Table 3.51 Fuel combustion emissions from residential sector, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.4 category (%)
1990	13 875	132	1.43	17 939	440 249	52.8
1995	12 973	124	1.38	16 815	439 460	44.3
2000	12 028	106	1.21	15 328	440 543	40.4
2005	17 827	98	1.05	20 850	477 590	48.7
2010	42 092	151	1.22	46 641	686 593	68.6
2011	45 153	130	1.02	49 059	727 195	65.6
2012	47 263	137	1.04	51 382	737 803	83.0
2013	41 996	113	0.91	45 395	706 439	80.1
2014	41 228	111	0.88	44 582	696 837	79.1
2015	30 479	58	0.55	32 258	587 205	49.4
2016	31 721	59	0.57	33 518	600 881	51.4
2017	40 620	71	0.60	42 764	705 283	58.2
2018	37 192	59	0.49	38 988	636 194	62.0
2019	41 922	66	0.53	43 910	717 860	63.3
2020	48 240	76	0.59	50 522	802 223	67.1
2021	48 408	69	0.55	50 484	814 229	66.9
2022	47 409	60	0.52	49 224	827 099	65.5

Total GHG emission in 1.A.4.b category decreased 1 260 kt CO_2 eq. (2.5% of decrease) from 2021 to 2022.

Methodological Issues:

GHG emissions from 1.A.4.b sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EFs are used for emission estimation. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs. GHG emissions from biomass were estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 7.07% for liquid fuels, 14.14% for solid fuels, 5% for gaseous fuels and 300% for biomass.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A4b category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined.

CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC Guidelines.

Recalculation:

Emissions from this sector were recalculated due to sub sectoral allocation for the years 1990-2014.

Planned Improvement:

There is no planned improvement in this sector.

3.2.7.3. Agriculture/Forestry/Fisheries (Category 1.A.4.c)

Source Category Description:

The source category is only including the emission from the consumption of fuel in agricultural activities.

The AD of this sub-category generally is consistent during the period 1990-2011, increasing gradually. However, there was a drop in 2012 due to a classification problem with diesel oil consumption. Before 2012, diesel fuel was distributed in accordance with the definitions given below:

- Diesel oil (sulfur content up to 10 mg/kg) is used for road transportation
- Rural diesel (maximum sulfur content of 1000 mg/kg) is used in agricultural sector.

Based on this definition, diesel oil consumption in road transportation and agriculture was separated. But "Technical Regulation Notification on Types of Diesel" entered into force by being published on Official Gazette No. 27312 dated 08.07.2009 and restricted diesel oil sulfur content up to 10 mg/kg. The deadline for implementation is extended to April 2011. After April 2011, it is not possible to separate the different use of diesel fuel. So in 2012 energy balance table, some of diesel oil used in agricultural sector is included in road transportation. Due to this fact, a sharp increase in diesel consumption in road transportation and a sharp decrease in fuel consumption of Agriculture/Forestry/Fisheries sector were observed. MENR worked on agricultural association for modeling the agricultural diesel oil consumption. MENR disaggregated the diesel oil consumption data in agriculture sector by a comparison method in which total crop harvested area and petroleum products consumption data of similar countries are weighted to derive an indicator for Türkiye.

More than 90% of GHG emissions from agricultural sector is related to off road vehicles. The share of GHG emissions as CO_2 eq. from 1.A.4.c category in total other sectors is 14.5% in 2022 while it was 18.8% in 1990.

Table 3.52 Fuel combustion emissions from agriculture sector, 1990-2022

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.4 category (%)
1990	5 770	0.33	2.28	6 384	79 826	18.8
1995	7 340	0.42	2.90	8 121	101 548	21.4
2000	8 501	0.49	3.36	9 407	117 623	24.8
2005	9 095	0.52	3.60	10 063	125 832	23.5
2010	12 951	0.74	5.12	14 329	179 194	21.1
2011	15 112	0.87	5.96	16 716	209 260	22.3
2012	3 008	0.17	1.18	3 325	41 762	5.4
2013	2 350	0.14	0.88	2 588	32 992	4.6
2014	3 045	0.18	1.11	3 343	43 149	5.9
2015	8 797	0.51	3.38	9 707	122 772	14.9
2016	8 688	0.51	3.36	9 592	121 018	14.7
2017	9 112	0.53	3.52	10 059	127 007	13.7
2018	9 426	0.55	3.57	10 388	132 130	16.5
2019	9 742	0.57	3.71	10 741	136 568	15.5
2020	10 095	0.59	3.91	11 147	140 574	14.8
2021	9 952	0.58	3.82	10 981	138 909	14.6
2022	9 848	0.57	3.81	10 874	137 137	14.5

Total GHG emission in 1.A.4.c category decreased 108 kt CO_2 eq. (1% of decrease) from 2021 to 2022.

Methodological Issues:

GHG emissions from 1.A.4.c sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EFs are used for emission estimation for both stationary and mobile source categories. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs for both stationary and mobile source categories.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 14.14% for liquid fuels and 7% for gaseous fuels.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1.A.4.c category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined.

CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC Guidelines.

Recalculation:

There is no recalculation in this sector

Planned Improvement:

There is no planned improvement in this sector.

3.2.8. Other (Category 1.A.5)

No other sectors were covered under energy sector. Emissions from fuel delivered to the military is included under category 1.A.4.b for 1990-2022 periods and 1.A.4.a (for stationary) and 1.A.3 (for mobile) since 2015.

3.3. Fugitive Emission from Fuels (Category 1.B)

Source Category Description:

Fugitive emissions from extraction, processing, storage and transport of fossil fuels were covered under this category. CH_4 emission from coal mining, CH_4, CO_2, N_2O and NMVOC emissions from exploration, production/processing, transport/transmission, refining and storage of oil and natural gas were covered.

Table 3.53 Fugitive emissions from fuels, 1990-2022

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	220	185	0.0031	5 395
1995	209	164	0.0029	4 791
2000	168	257	0.0023	7 376
2005	142	239	0.0019	6 829
2010	156	347	0.0021	9 860
2011	151	382	0.0020	10 848
2012	144	395	0.0019	11 217
2013	146	358	0.0020	10 181
2014	145	430	0.0020	12 196
2015	155	223	0.0021	6 401
2016	158	359	0.0021	10 219
2017	157	275	0.0021	7 853
2018	174	318	0.0024	9 068
2019	183	405	0.0025	11 537
2020	195	356	0.0027	10 177
2021	210	424	0.0029	12 082
2022	218	427	0.0030	12 178

CO_2 and CH_4 are the main fugitive emissions in this category. CH_4 was emitted mainly from coal mining while CO_2 was emitted from venting and flaring. Fugitive emissions as CO_2 eq. have become 12 178 ktons in 2022. 32% of fugitive emissions as CO_2 eq. were from oil and gas systems and 68% were from solid fuels in the same year.

Table 3.54 Fugitive emissions from fuels by subcategory, 1990-2022

(kt CO_2 eq.)

Year	Total	Solid fuels	Oil and natural
1990	5 395	4 401	994
1995	4 791	3 654	1 137
2000	7 376	5 930	1 446
2005	6 829	4 818	2 012
2010	9 860	7 554	2 306
2011	10 848	8 175	2 673
2012	11 217	8 401	2 817
2013	10 181	7 735	2 445
2014	12 196	8 968	3 228
2015	6 401	3 324	3 076
2016	10 219	7 215	3 005
2017	7 853	4 492	3 360
2018	9 068	5 979	3 089
2019	11 537	8 305	3 232
2020	10 177	6 814	3 362
2021	12 082	7 969	4 113
2022	12 178	8 332	3 846

Methodological Issues:

GHG emissions from 1.B sector were calculated by using 2006 IPCC T1 approaches by TurkStat. Domestic production data for coal, oil and natural gas were taken from the national energy balance tables in kt. MENR provided domestic coal production in underground and surface mining details. Pipeline transmission amount of oil and natural gas and natural gas storage were provided by, Petroleum Pipeline Company (BOTAŞ) (which is state own enterprise and authority for crude oil and natural gas transportation and pipeline operation). Petroleum refining data were taken from Turkish Petroleum Refineries Co. (TÜPRAŞ). For LPG and gasoline distribution, consumption values presented in the national energy balance tables were used as AD.

Fugitive GHG emissions were estimated by using 2006 IPCC default EFs.

3.3.1. Solid fuels (Category 1.B.1)

Source Category Description:

This source category covers CH_4 emissions which occur during the surface and underground extraction of solid fuels and post-mining activities as well as abandoned underground mines. The emissions due to combustions of those fuels to support production activities is not included in this section. Under this category only fugitive CH_4 emissions are calculated.

Fugitive emissions from coal mining has increased to 363 t CO_2 eq. in 2022 due to the increase in the underground mining activities with respect to previous year.

Table 3.55 Fugitive emissions from solid fuels, 1990-2022

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	NE	157	NO,NE	4 401
1995	NE	131	NO,NE	3 654
2000	NE	212	NO,NE	5 930
2005	NE	172	NO,NE	4 818
2010	NE	270	NO,NE	7 554
2011	NE	292	NO,NE	8 175
2012	NE	300	NO,NE	8 401
2013	NE	276	NO,NE	7 735
2014	NE	320	NO,NE	8 968
2015	NE	119	NO,NE	3 324
2016	NE	258	NO,NE	7 215
2017	NE	160	NO,NE	4 492
2018	NE	214	NO,NE	5 979
2019	NE	297	NO,NE	8 305
2020	NE	243	NO,NE	6 814
2021	NE	285	NO,NE	7 969
2022	NE	298	NO,NE	8 332

In 2022 the amount of coal mined have been increased by 11.8% and become 95 312 ktons. In 2022, the emissions from coal mining activities have been increased by 4.6% and become 8 332 ktons CO_2 eq.

Figure 3.32 Domestic coal production 1990-2022

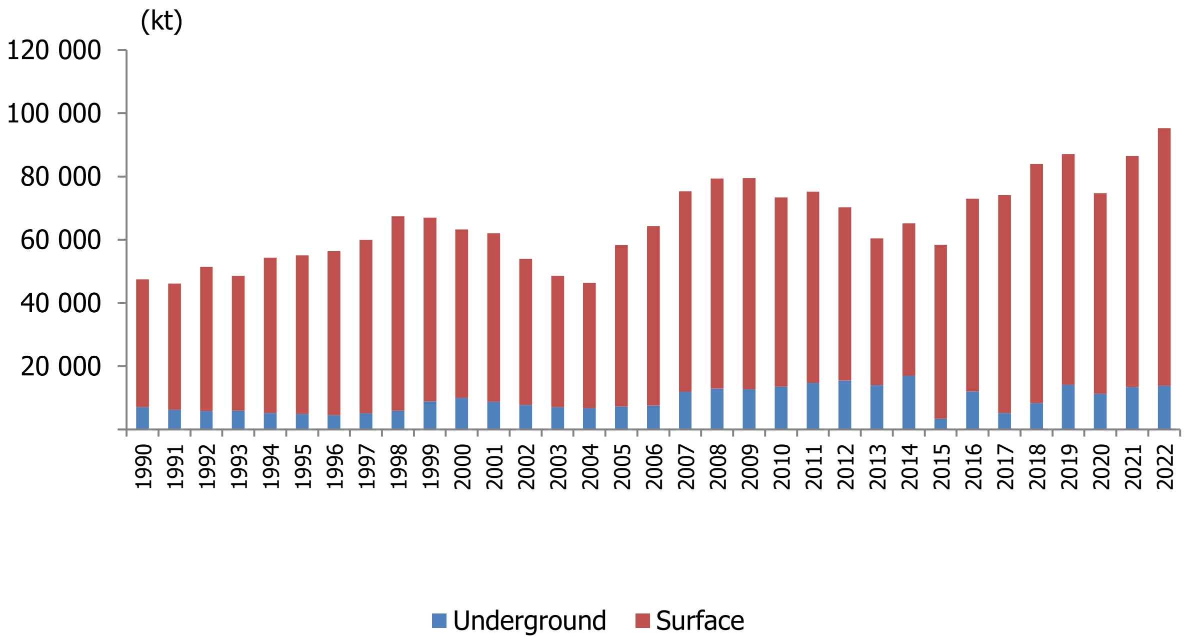


Figure 3.33 CH_4 emissions from coal mining, 1990-2022

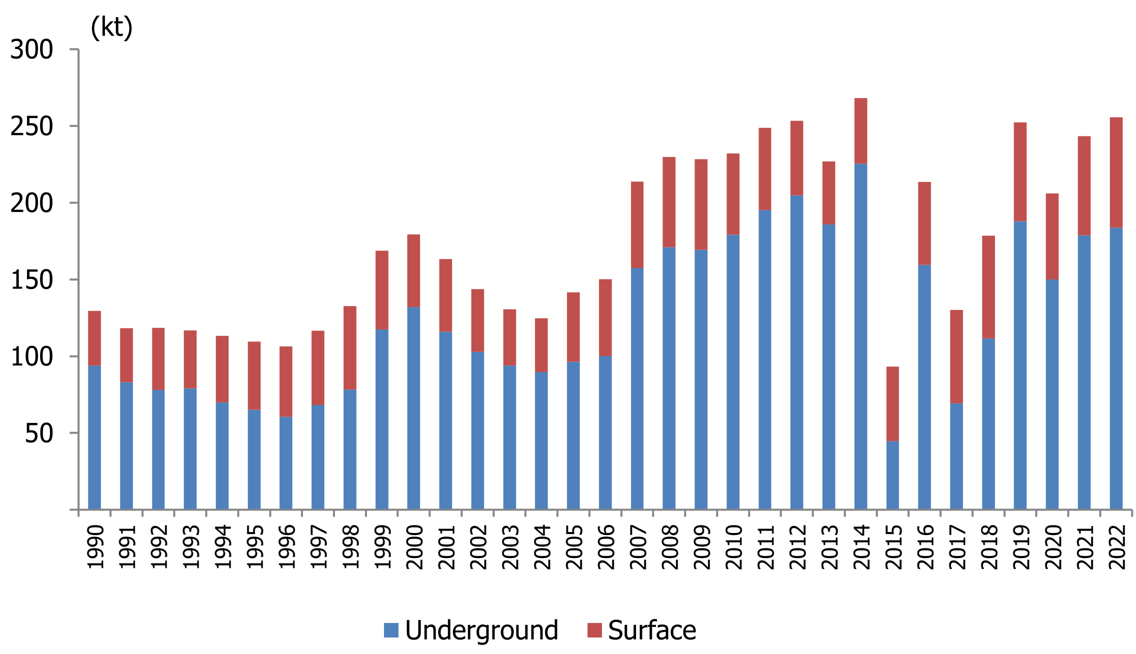


Table 3.56 Fugitive emissions from abandoned coal mines,1990-2022

(kt)

Year	CO_2	CH_4	CO_2 eq.
1990	NE	11.5	323
1995	NE	8.2	230
2000	NE	10.2	287
2005	NE	13.3	372
2010	NE	8.3	233
2011	NE	11.6	326
2012	NE	14.2	397
2013	NE	20.1	563
2014	NE	17.2	482
2015	NE	15.2	425
2016	NE	17.5	490
2017	NE	15.5	434
2018	NE	14.0	392
2019	NE	12.8	359
2020	NE	11.9	332
2021	NE	11.1	310
2022	NE	10.4	291

Methodological Issues:

GHG emissions from 1.B.1 sector were calculated by using 2006 IPCC T1 approaches by TurkStat. Domestic coal production data were taken from the national energy balance tables. MENR provided domestic coal production in underground and surface mining details.

Fugitive GHG emissions from coal mines were estimated by using 2006 IPCC default EFs. Both mining and post mining fugitive emissions from underground and surface mines were estimated.

The fugitive emissions from abandoned underground mines are calculated with tier 2 methodology shown below.

Methane Emissions = (Number of coal mines abandoned remaining unflooded) x (Fraction of gassy mines) x (Average emission rate) x (Emission factor) x (Conversion factor) See eqn. 4.1.11 in 2006 IPCC Guidelines Volume 1. All parameter used in this equation are default values.

Fraction of gassy mines is 100%

Average emission rate is 5.735 m^3/year

Emission factor is calculated as $EF = (1+aT)^b$ where a and b are default values for either lignite or hard coal and T is the years elapsed since abandonment. The coefficients used in the calculations is given below.

Table 3.57 Coefficients used in the calculation of abandoned coal mines methane emission

Coal type	a	b
Hard coal	3.72	-0.42
Lignite	0.27	-1

(Source: see eqn 4.1.12 and table 4.1.9 in 2006 IPCC Guidelines Volume 1)

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 16.6% for coal production.

Default EFs uncertainty for coal mining was taken from 2006 IPCC Guidelines Vol.2 Table 4.1.2 and Table 4.1.4. CH_4EFs uncertainty value was determined as 557%.

Source-Specific QA/QC and Verification:

Quality control for 1.B.1 category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined.

CH_4IEFs are in the range of 2006 IPCC Guidelines.

Recalculation:

There is recalculation in this sector due to the amount of coal as recommended by ERT.

Planned Improvement:

Since the category is a key category in terms of emission trend of CH_4, the tiers in CH_4 estimation needs to be increased. Detailed investigation has been performed to find out the availability of country specific or basin specific EFs within both general directorates for lignite and hard coal structured under the MENR, namely, DG Turkish Lignite Enterprises and DG Turkish Hard Coal Enterprises. However, information for the generation of country-specific EFs are not available centrally in those coal authorities. Therefore, it is necessary to communicate and cooperate with mining enterprises directly to search the availability of required information for T2 estimation of CH_4.

3.3.2. Oil and natural gas (Category 1.B.2)

Source Category Description:

This source category covers fugitive CO_2, N_2O, CH_4 emissions from exploration, production (processing), transport (transmission), refining and storage of oil and natural gas. Three sub-source categories, oil (1.B.2.a), natural gas (1.B.2.b) and venting and flaring (1.B.2.c) were covered under this category.

This source category is a key category in terms of emission level and trend of CH_4emission. CO_2 emissions are mainly coming from oil production. About 95% of CO_2 emissions from oil and gas systems are venting and flaring emissions during oil extraction and production. CH_4 emissions are mainly coming from oil production and pipeline transmission and distribution of natural gas. In parallel to the increase in natural gas transmission and distribution, the greenhouse gas emissions in 1.B.2 category has increased from 994 kt CO2 eq. in 1990 to 3 846 kt in 2022.

Table 3.58 Fugitive emissions from oil and natural gas systems,1990-2022

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	220	28	0.0031	994
1995	209	33	0.0029	1 137
2000	168	46	0.0023	1 446
2005	142	67	0.0019	2 012
2010	156	77	0.0021	2 306
2011	151	90	0.0020	2 673
2012	144	95	0.0019	2 817
2013	146	82	0.0020	2 445
2014	145	110	0.0020	3 228
2015	155	104	0.0021	3 076
2016	158	102	0.0021	3 005
2017	157	114	0.0021	3 360
2018	174	104	0.0024	3 089
2019	183	109	0.0025	3 232
2020	195	113	0.0027	3 362
2021	210	139	0.0029	4 113
2022	218	130	0.0030	3 846

Figure 3.34 Oil production, 1990–2022

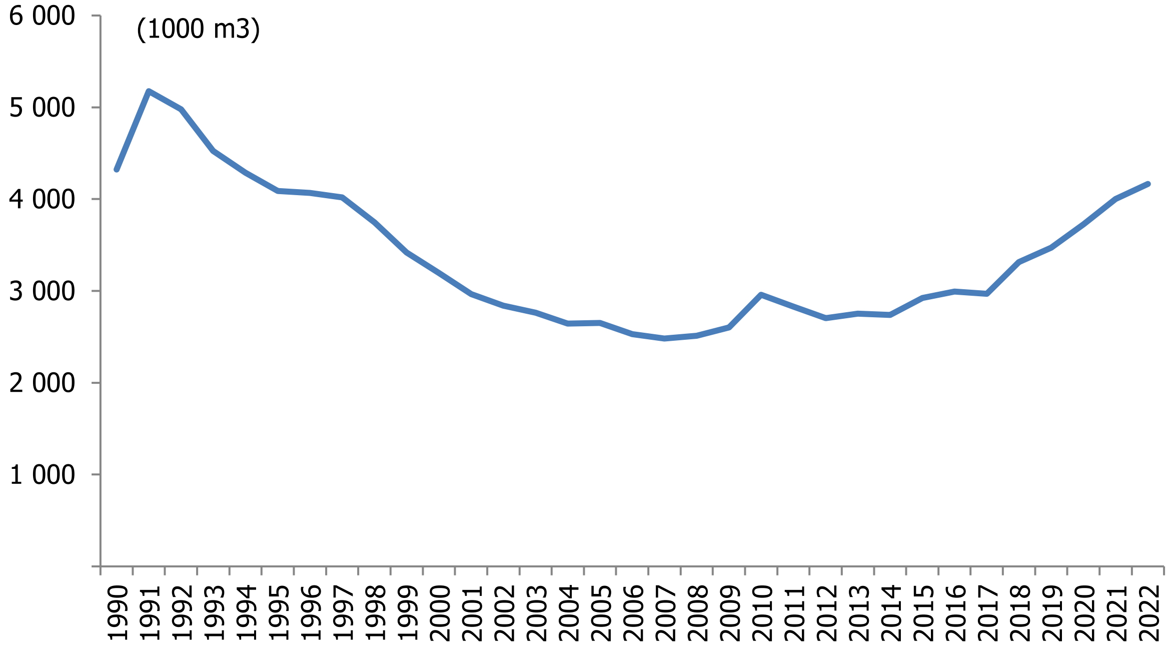


Figure 3.35 Natural gas production, 1990-2022

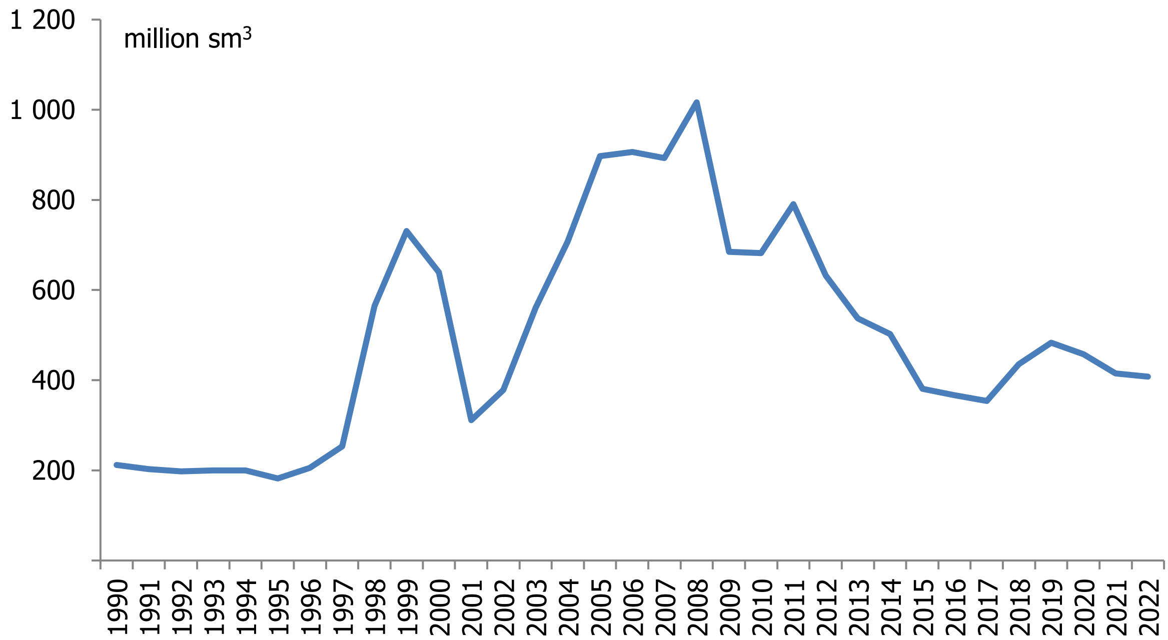


Figure 3.36 Natural gas transmission by pipeline, 1990-2022

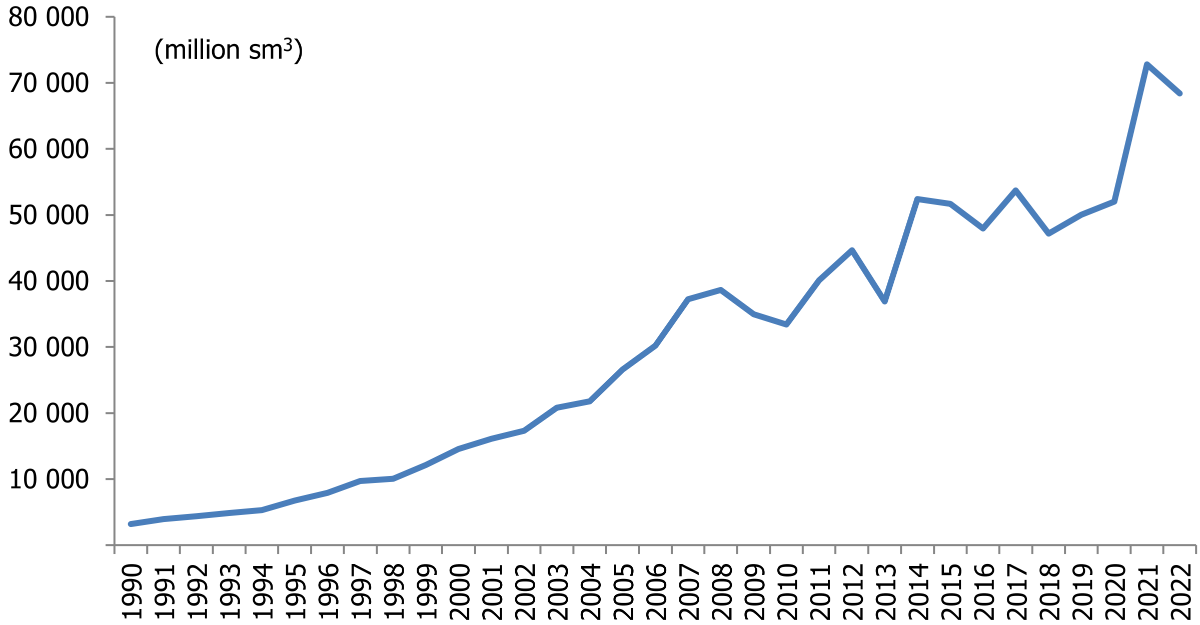
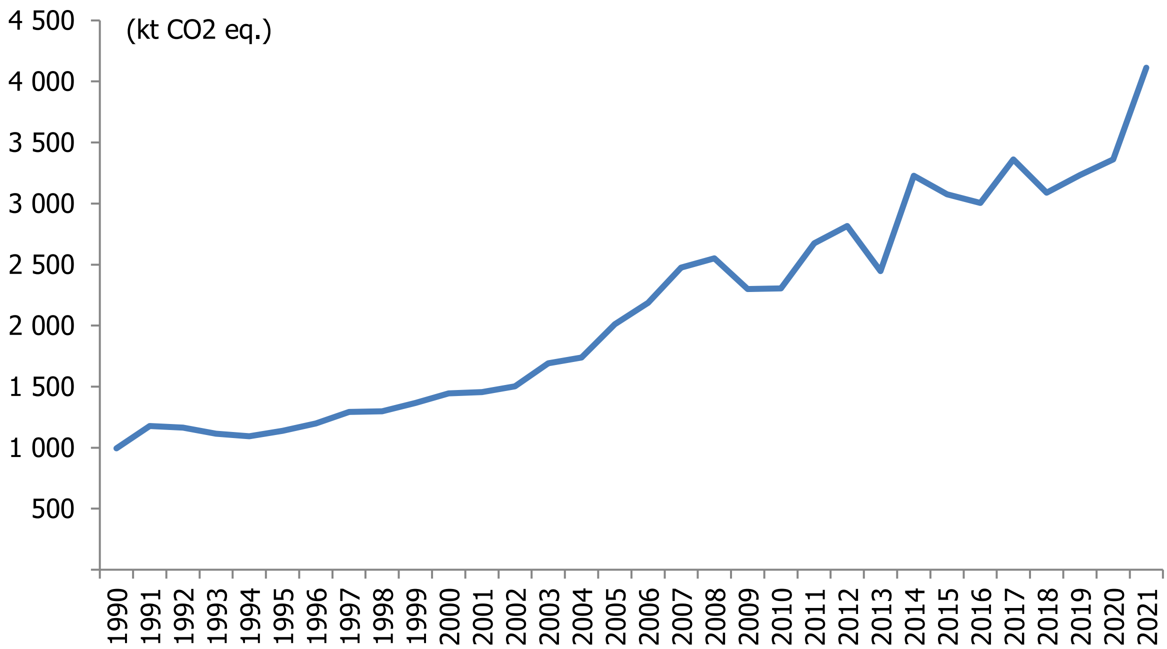


Figure 3.37 Fugitive emissions from oil and gas system, 1990-2022



Methodological Issues:

GHG emissions from 1.B.2 sector were calculated by using 2006 IPCC T1 approaches by TurkStat.

Domestic production data for oil and natural gas were taken from the national energy balance tables in kt. Pipeline transmission amount of oil and natural gas and data related to storage of natural gas were provided by BOTAŞ, Petroleum Pipeline Company (which is a state own enterprise and authority for crude oil and natural gas transportation and pipeline operations). Petroleum refining data were taken from Turkish Petroleum Refineries Co. (TÜPRAŞ). For LPG and gasoline distribution, consumption values for those fuels were used from the national energy balance tables.

Fugitive GHG emissions from oil and natural gas systems were estimated by using 2006 IPCC Guidelines default EFs. Since the category is a key category in terms of emission level and trend of CH_4, the tiers in estimating CH_4 emission need to be increased. Detailed investigation has been performed to find out the availability of country specific EF. It is necessary to communicate and cooperate with related authorities directly to search the availability of required information for Tier 2 estimation of CH_4. It is planned to continue with investigations.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 7% for oil and gas systems.

Default EFs uncertainty for oil and gas systems was taken from 2006 IPCC Guidelines Vol.2 Table 4.2.4. Oil and gas systems EFs uncertainty values were determined as 334% for CO_2, 356% for CH_4, and 224% for N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1.B.2 category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined.

IEFs are controlled and they are all in the range of 2006 IPCC default values.

Recalculation:

There is no recalculation in this category.

Planned Improvement:

In order to increase the tiers for CH_4 emission estimation, availability of detailed information have been searched. It is planned to continue the investigation to find out the availability or possibility of availability of appropriate data for higher tiers.

3.4. CO_2 Transport and Storage (Category 1.C)

Source Category Description:

This source category covers only fugitive CO_2 from pipeline transportation of CO_2. This source category is not a key category. CO_2 emissions were calculated on the basis of pipeline length as 0.126 kt for whole 1990-2017 period.

Methodological Issues:

CO_2 emissions from 1C sector were calculated by using 2006 IPCC Tier 1 approaches by TurkStat. Pipeline length was obtained from Turkish Petroleum Incorporation. Pipeline length has not changed with respect to the previous inventory year. Fugitive CO_2 emissions from CRT category 1C were estimated by using 2006 IPCC Guidelines default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from Turkish Petroleum Incorporation. AD uncertainty was considered 2% as indicated in Table 2.15 of 2006 IPCC Guidelines Vol.2. Since AD have been taken directly from the company uncertainty level for survey data were considered and to be conservative the maximum uncertainty value was used.

EFs uncertainty was taken from 2006 IPCC Guidelines Vol.2 Table 5.2. Uncertainty values were considered as 200% for CO_2.

Recalculation:

There is no recalculation in this category.

Planned Improvement:

There is no planned improvement for this category.

4. INDUSTRIAL PROCESSES AND PRODUCT USE (CRT Sector 2)

4.1. Sector Overview

The GHG emissions from industrial processes and product use are released as a result of manufacturing processes. This category includes emissions from processes and excludes emissions from fuel combustion used to supply energy for carrying out the processes. Therefore, emissions from industrial processes are referred to as non-combustion.

The key categories contributing to CO_2 emissions in the industrial processes and product use (IPPU) sector are the production of cement, lime, iron and steel, HFCs from product use as ODS substitutes, and other process uses of carbonates in various industrial activities.

In 2022, the total GHG emissions from industrial processes and product use in Türkiye were 69 908 kt CO_2 eq., which represents 13.9% of the total emissions, including the Land Use, Land-Use Change, and Forestry (LULUCF) sector, and 12.5% of all emissions excluding LULUCF.

The most significant GHG emission sources in the IPPU sector in 2022 were cement production with a 7.1% share and iron and steel production with a 1.7% share of the total national GHG emissions excluding LULUCF.

Table 4.1 Industrial processes and product use sector emissions, 2022

(kt CO_2 eq.)

GHG sources and sink categories	CO_2	CH_4	N_2O	HFCs/ PFCs/SF_6	Total
Industrial processes and product use	57 911	17	1 580	10 400	69 908
A. Mineral industry	46 010	NA	NA	NA	46 010
B. Chemical industry	1 364	NO,IE,NA	1 580	NA	2 944
C. Metal industry	10 389	17	NA	52	10 458
D. Non-energy products from fuels and solvent use	148	NA,NE	NA,NE	NA	148
E. Electronic Industry	NA	NA	NA	71	71
F. Product uses as ODS substitutes	NA	NA	NA	10 184	10 184
G. Other product manufacture and use	NA	NA	NA	94	94
H. Other	NE,NA	NE,NA	NA	NA	NE,NA

The main gas emitted by the IPPU sector was CO_2, contributing to 82.8% (57 911 kt) of the sector's emissions in 2022. HFCs, PFCs and SF_6 contributed 14.9% (10 400 kt CO_2 eq.) while the share of N_2O emissions was 2.3% (1 580 CO_2 eq.) and CH_4 emissions was 0.02% (17 kt CO_2 eq.).

Table 4.2 Industrial processes and product use emissions by gas, 1990- 2022
(kt CO_2 eq.)

Years	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
1990	21 312	9	946	NO	425	NO	22 691
1995	24 102	8	893	NO	368	NO	25 371
2000	24 804	10	753	105	368	14	26 054
2005	31 325	10	1 203	1 044	359	18	33 960
2010	43 889	11	1 470	2 789	348	67	48 575
2011	48 346	12	1 548	3 142	326	69	53 443
2012	49 880	14	1 580	3 892	244	70	55 679
2013	52 788	15	1 588	4 095	180	70	58 736
2014	53 043	16	1 608	4 519	168	80	59 434
2015	53 259	17	1 293	4 425	82	83	59 160
2016	57 291	19	1 084	4 694	34	81	63 203
2017	60 053	18	1 028	4 832	23	124	66 077
2018	60 714	19	1 621	4 647	9	138	67 148
2019	51 120	18	1 794	5 249	15	159	58 355
2020	59 247	17	1 784	6 008	9	175	67 241
2021	65 993	19	1 799	6 716	6	182	74 715
2022	57 911	17	1 580	10 184	8	208	69 908

Table 4.2 presents the development of the emissions by gas for the IPPU sector. Total emissions from industrial process and product use increased by 208.1% between 1990 (22 691 kt CO_2 eq.) and 2022 (69 908 kt CO_2 eq.).

Table 4.3 Overview of industrial processes and product use sector emissions, 1990-2022

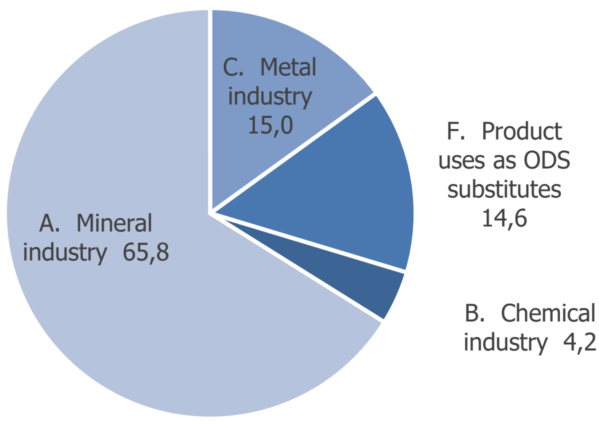
Year	A. Mineral industry		B. Chemical industry		C. Metal industry		D. Non-energy products from fuels and solvent use		Industrial Processes and Product Use Total	
	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)
1990	13 424	59.2	1 511	6.7	7 573	33.4	183	0.8	22 691	100.0
1995	17 548	69.2	1 365	5.4	6 255	24.7	203	0.8	25 371	100.0
2000	18 418	70.7	968	3.7	6 273	24.1	277	1.1	26 054	100.0
2005	23 247	68.5	1 794	5.3	7 411	21.8	446	1.3	33 960	100.0
2010	34 087	70.2	1 720	3.5	9 480	19.5	432	0.9	48 575	100.0
2011	36 237	67.8	2 560	4.8	10 582	19.8	854	1.6	53 443	100.0
2012	37 315	67.0	2 772	5.0	11 025	19.8	606	1.1	55 679	100.0
2013	40 539	69.0	2 381	4.1	11 117	18.9	534	0.9	58 736	100.0
2014	40 885	68.8	2 584	4.3	10 967	18.5	399	0.7	59 434	100.0
2015	40 305	68.1	2 631	4.4	11 450	19.4	266	0.5	59 160	100.0
2016	43 821	69.3	2 024	3.2	12 437	19.7	146	0.2	63 203	100.0
2017	46 474	70.3	1 769	2.7	12 731	19.3	152	0.2	66 077	100.0
2018	46 213	68.8	3 144	4.7	12 806	19.1	206	0.3	67 148	100.0
2019	38 548	66.1	2 921	5.0	11 382	19.5	138	0.2	58 355	100.0
2020	47 064	70.0	2 868	4.3	11 049	16.4	134	0.2	67 241	100.0
2021	50 875	68.1	3 913	5.2	12 911	17.3	170	0.2	74 715	100.0
2022	46 010	65.8	2 944	4.2	10 458	15.0	148	0.2	69 908	100.0

Table 4.3 Overview of industrial processes and product use sector emissions, 1990-2022 (cont'd)*

Year	E. Electronic industry		F. Product uses as ODS substitutes		G. Other product manufacture and use		Industrial Processes and Product Use Total	
	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)
1990	-	0.0	-	0.0	-	0.0	22 691	100.0
1995	-	0.0	-	0.0	-	0.0	25 371	100.0
2000	-	0.0	105	0.4	14	0.1	26 054	100.0
2005	-	0.0	1 044	3.1	18	0.1	33 960	100.0
2010	44	0.1	2 789	5.7	23	0.0	48 575	100.0
2011	44	0.1	3 142	5.9	25	0.0	53 443	100.0
2012	44	0.1	3 892	7.0	26	0.0	55 679	100.0
2013	44	0.1	4 095	7.0	27	0.0	58 736	100.0
2014	44	0.1	4 519	7.6	37	0.1	59 434	100.0
2015	44	0.1	4 425	7.5	40	0.1	59 160	100.0
2016	44	0.1	4 694	7.4	37	0.1	63 203	100.0
2017	47	0.1	4 832	7.3	73	0.1	66 077	100.0
2018	59	0.1	4 647	6.9	73	0.1	67 148	100.0
2019	59	0.1	5 249	9.0	58	0.1	58 355	100.0
2020	60	0.1	6 008	8.9	57	0.1	67 241	100.0
2021	67	0.1	6 716	9.0	64	0.1	74 715	100.0
2022	71	0.1	10 184	14.6	94	0.1	69 908	100.0

*The icon "-" indicates notation keys "NO, NA, IE" as shown in the table.

Figure 4.1 Emissions from industrial processes and product use by subsector, 2022



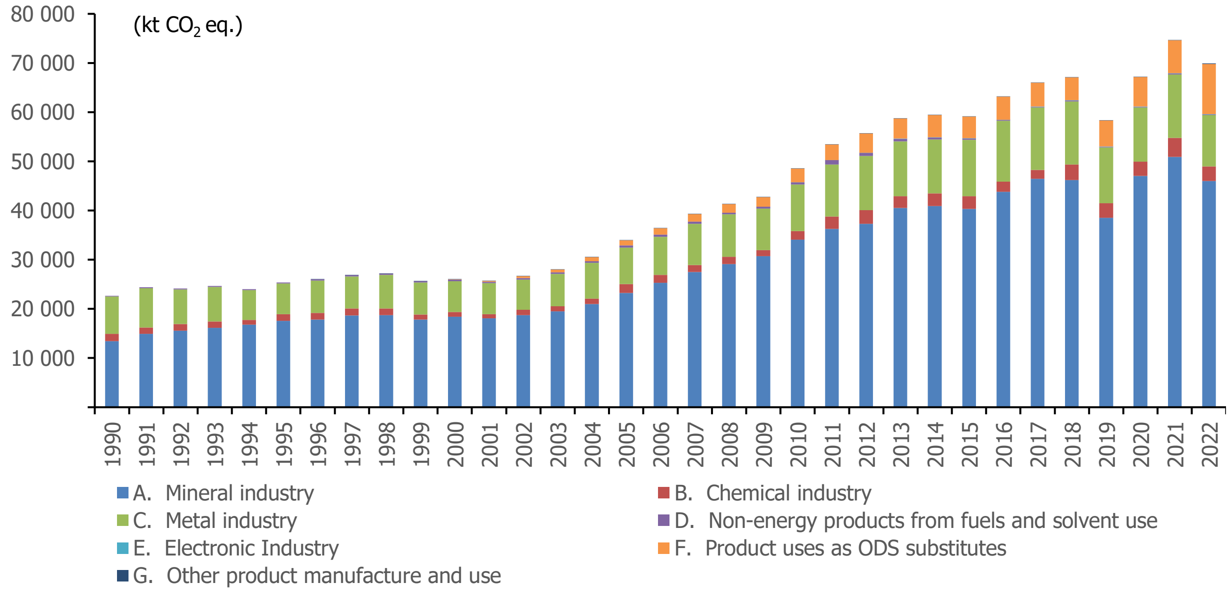
The mineral industry contributed 65.8% of the IPPU sector's emissions in 2022, while the metal industry contributed 15%, product uses as ODS substitutes contributed 14.6%, and the chemical industry contributed 4.2%.

Between the years 1990-2022, the average shares of the mineral industry, metal industry and chemical industry are 68.3%, 22.4% and 4.4%, respectively.

The increases in sectoral emissions observed over the long term are primarily due to the growth in emissions associated with the mineral industry, specifically cement production, and the metal industry, particularly iron and steel production. These emissions have increased as a result of industrial growth and the rising demand for construction materials.

Each source category's contribution to total emissions and to sectoral trends within the IPPU sector between 1990 and 2022 is shown in Figure 4.2.

Figure 4.2 Emissions from industrial processes and product use by subsector, 1990–2022

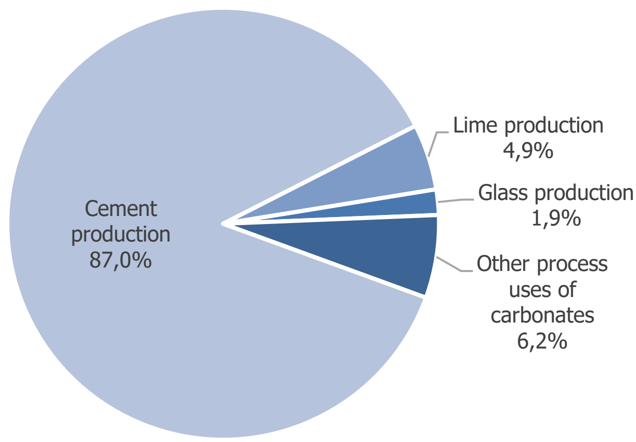


4.2. Mineral Industry (Category 2.A)

The mineral industry includes non-fuel CO_2 emissions from cement and lime production, limestone and dolomite use, glass production, ceramics production, soda ash use, and non-metallurgical magnesia production.

Figure 4.3 presents the share of CO_2 emissions in the mineral industry for the year 2022. The dominant sector is cement production having a 87% share of CO_2 emissions in the mineral industry. The second and third sectors are other process uses of carbonates and lime production, contributing 6.2% and 4.9% of CO_2 emissions, respectively. Glass production is responsible for 1.9% of emissions in the mineral industry.

Figure 4.3 Share of CO_2 emissions from mineral production, 2022



4.2.1 Cement production (Category 2.A.1)

Source Category Description:

Cement production causes CO_2 emissions due to calcination reaction of limestone during production and these emissions are reported under 2.A.1 CRT category. Additionally, cement production is an energy-intensive process. Heating up the kiln with its load to such a high temperature is extremely energy-consuming. Most of the kilns in Türkiye use coal, petroleum coke, lignite as the primary energy sources. The emissions resulting from the combustion of these fuels to heat up the kilns are included in the 1.A.2f CRT category.

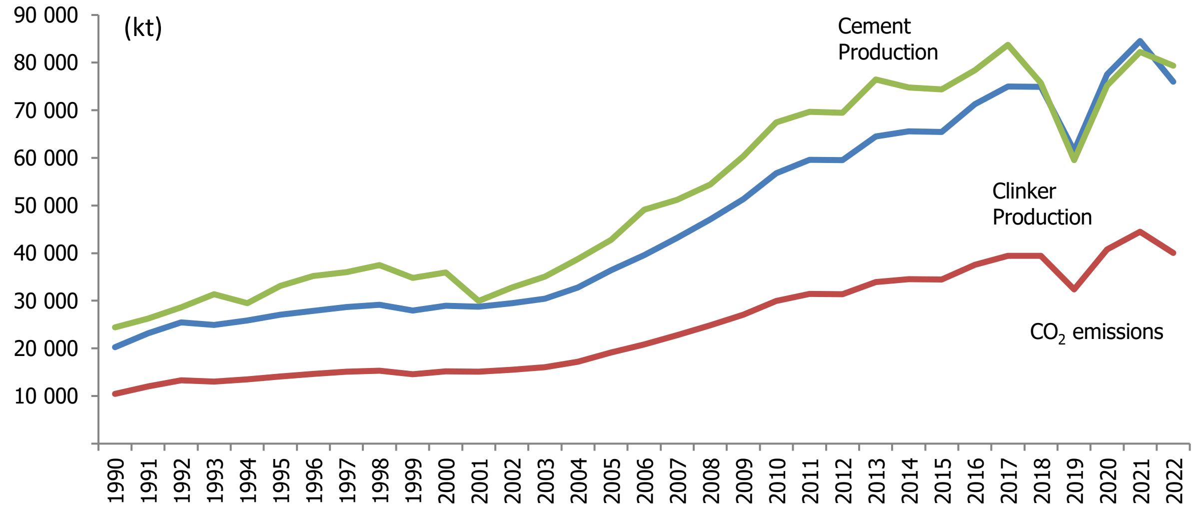
In cement production, limestone is fed to the cement kiln and heated up to 1400-1500 °C to produce lime. At this temperature, calcium carbonate ($CaCO_3$) breaks down into lime (CaO) and carbon dioxide (CO_2) according to the following reaction:

$$CaCO_3 \rightarrow CaO + CO_2$$

Then, silica-containing materials are combined with the lime to make the clinker, which is the most important intermediate product for cement production. Clinker is also traded as a commodity. Cement is produced by mixing and grinding the clinker with small amount of gypsum and potentially other materials (e.g slag). All the CO_2 emissions are released from the kilns during the clinker production step.

Figure 4.4 below shows the trend at clinker production and the related CO_2 emissions between 1990 and 2022.

Figure 4.4 Trend at clinker, cement production and related CO_2 emissions, 1990-2022



Türkiye began cement production in 1911 and was a cement importer untill 1970s. Cement exports from Türkiye started in 1978. By 2022, Türkiye had become Europe's largest cement producer, with a 96 million tons of clinker production capacity. The production plants are distributed all over the country because transportation costs in the cement sector are quite high. In Türkiye mostly portland cement is produced, but slag cement, puzzolan added cement, and their modifications are also produced.

As can be seen from the figures above, CO_2 emissions increased by 283% between 1990 and 2022. The construction sector and cement exports are the strongest drivers in the cement sector. Except for some minor reductions in 2001 due to Türkiye's economic recessions and in 2015 due to conflicts in Türkiye's southern neighborhood (Syria and Iraq), the cement industry showed a continuous growth untill 2018. After 2018, due to a contraction domestic demand in the construction sector stemmed from the recession and pandemic, cement production decreased. Consequently, cement producers preferred to export clinker during this period. In 2022, clinker production was 76 007 kt, resulting in 40 007 kt of CO_2 emission. By 2022, cement production decreased by 3,5% compared to 2021.

Methodological Issues:

The estimation of CO_2 emissions is accomplished by applying a country-specific EF, in tonnes of CO_2 released per tonne of clinker produced, to the annual national clinker output, corrected with the fraction of clinker that is lost from the kiln in the form of cement kiln dust (CKD). This follows the T2 methodology in the 2006 IPCC Guidelines as illustrated below.

$$CO_2\, emissions = M_{Cl} \cdot EF_{Cl} \cdot CF_{CKD}$$

Where:

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

Collection of activity data

There are 56 cement plants in Türkiye and most of them are members of Turkish Cement Manufacturers' Association (TurkCimento). These plants report their activity data to TurkCimento on a monthly basis, and TurkCimento publishes the data as industry-specific statistics on their website. The annual amount of national clinker production in Turkey is gathered from the clinker production statistics provided by TurkCimento. For plants that are not members of TurkCimento, their activity data is collected through surveys.

Choice of emission factor

In the 2016 inventory, data for the carbonate content in clinker was gathered from the production plants for the years 1990-2015. It was determined that the average weight percentage of CaO varies between 64% - 66% throughout the time series, and it was 65.8% in 2015. The corresponding EF in 2015 is 0.515913. This study reveals that CaO content does not vary over the years and was not iterated again for the latest inventory. Türkiye applies the IPCC default CKD correction factor of 1.02. The table below shows all the activity data and emission factors used for the emission calculation in the time series, along with annual CO_2 emissions from clinker production.

Table 4.4 CO_2 emissions from cement production, 1990-2022

Year	Clinker Production (kt)	Cemet Production (kt)	Cao Content (%)	CO_2 EF	CKD	CO_2 Emission (kt)
1990	20 252	24 416	64.4	0.506	1.02	10 445
1995	27 094	33 140	65.2	0.511	1.02	14 133
2000	28 950	35 953	65.5	0.514	1.02	15 184
2005	36 382	42 787	65.6	0.515	1.02	19 117
2010	56 798	67 447	65.9	0.517	1.02	29 977
2011	59 579	69 643	66.0	0.518	1.02	31 454
2012	59 508	69 466	65.9	0.517	1.02	31 372
2013	64 482	76 484	65.7	0.516	1.02	33 913
2014	65 594	74 768	65.7	0.516	1.02	34 498
2015	65 433	74 401	65.7	0.516	1.02	34 441
2016	71 298	78 437	65.7	0.516	1.02	37 528
2017	74 985	83 735	65.7	0.516	1.02	39 469
2018	74 880	75 746	65.7	0.516	1.02	39 413
2019	61 458	59 511	65.7	0.516	1.02	32 349
2020	77 539	75 172	65.7	0.516	1.02	40 813
2021	84 533	82 232	65.7	0.516	1.02	44 494
2022	76 007	79 347	65.7	0.516	1.02	40 007

Uncertainties and Time-Series Consistency:

The uncertainty value of the AD was estimated to be ±5% with error propagation equations. Although aggregated plant production data was used for the calculation, plant specific production data also collected, and their summation was compared with the aggregated production data supplied by TurkCimento and they were found to be close for 2015. The uncertainty value of the EF is 2% due to chemical analysis of clinker to determine the CaO percentage and default factor used for CKD.

Source-Specific QA/QC and Verification:

Clinker production data is gathered by the TurkCimento and reported monthly on their website. The activity data of plants that are not members of TurkCimento are collected with questionnaires. However, TurkCimento do not report on CaO contents in the clinker. The annual average CaO contents of all the cement factories are obtained through a questionnaire, and at the same time, clinker production amounts of the factories are also collected for quality assurance purposes in 2017. Details of this study can be found in inventory submitted in 2018.

Moreover, the clinker production data gathered from the TurkCimento and PRODCOM (Turkish national industrial production statistics) are compared and found to be consistent. In 2018, one of the clinker production plants was visited, and discussed on CKD data. According to the research, due to the production system being sealed, it was assumed that there is no kiln dust.

In this submission, emission calculations were performed using two different software programs, and the results were compared to minimize calculation errors.

QA/QC procedures are implemented for each category to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculation:

The new plant which became operational in 2021, increased CO_2 emissions by 267.3 kt.

Planned improvements:

In the next years, it is planned to calculate emissions using the MRV data provided by MoEUCC.

4.2.2 Lime production (Category 2.A.2)

Source Category Description:

The word "lime" refers to the product obtained by calcining limestone. Lime production involves a series of steps, including quarrying the raw material, crushing and sizing it, and carrying out the process of calcination. Limestone is a naturally occurring and abundant rock that primarily consists of calcium carbonate, with possible traces of magnesium carbonate. The production of lime commences with the extraction of limestone from quarries. The limestone is then crushed, screened, and subjected to heating in a kiln. This thermal treatment causes the calcination of calcium carbonate molecules, as well as any present magnesium carbonate molecules. During the calcination stage, the burning of limestone ($CaCO_3$) at high temperatures (900-1200°C) in the kiln generates CO_2, which is released into the atmosphere. Similarly, magnesium carbonate ($MgCO_3$) undergoes decomposition to form MgO and CO_2. The chemical equations representing the calcination reactions are as follows:

$$CaCO_3 \rightarrow CaO + CO_2$$

$$MgCO_3 \rightarrow MgO + CO_2$$

Lime production results in CO_2 emissions due to calcination reaction of limestone during production process and these emissions are reported under 2.A.2 CRT category. Furthermore, lime production is an energy intensive process. Heating up the kiln with its load to such a high temperature is extremely energy consuming. Most of the kilns in Türkiye primarily rely on coal, petroleum coke, lignite as the primary energy sources. The emissions arising from the combusting of these fuels to heat the kilns are included in 1.A.2.f CRT category.

In Türkiye lime is produced by a wide range of technology from old fashioned kilns to computer controlled plants. The majority of lime plants in Türkiye are technologically advanced or have been modified to incorporate the best available technologies. The presence of outdated lime plants is relatively minor in Türkiye, and their numbers are gradually declining each year. Lime producers can be categorized into two groups: those producing for the market and those producing for internal consumption. Sugar refiners, soda ash manufacturers, and iron and steel manufacturers produce lime for their own use. However, sugar refiners and soda ash producers use the produced CO_2 in their process steps and CO_2 is absorbed. Consequently, lime production of the sugar refiners and soda ash producers do not contribute to the greenhouse gas inventory.

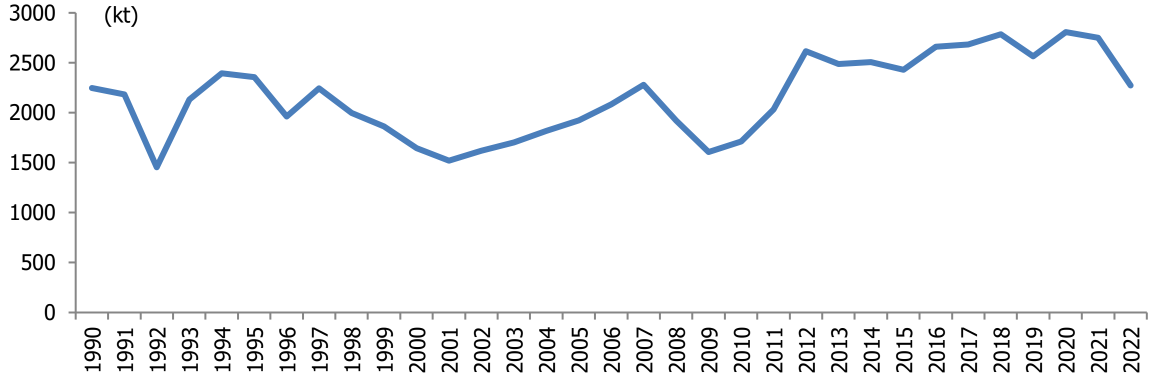
In the sugar refining process, Türkşeker, which currently operates 15 sugar factories with daily capacities ranging from 1750 to 8500 tons of beet, produces lime used in the treatment process within the lime quarries located at the factory sites. A mixture of limestone and coke is supplied to the lime kiln. After limestone decomposes into lime and CO_2, lime is quenched with water and lime milk is prepared to be used to remove impurities from raw sugar juice. The CO_2 drawn from the upper part of the furnace is used to precipitate the excess lime used in the treatment.[4] The CO_2 emitted is reabsorbed into the lime cake and emissions are balanced by the CO_2 sink in sugar production.

Almost all of the lime produced in Türkiye comprises quick lime and dolomitic lime, with a negligible amount of hydraulic lime production.

The lime produced in Türkiye is mostly used in the manufacturing and construction sector. It is seen in the graph, emissions are decreased remarkably in 1992, in 2000-2001 period and in 2008-2009 period due to slow down of the construction sector and economic recessions. The emissions from lime production seems to be going to increase in the future, as the manufacturing and construction sectors continue to grow overall and the demand for lime increases. The Figure 4.5 shows the trend at lime production and the related CO_2 emissions between 1990 and 2022.

[4] Türkşeker website, Sugar production technology, https://www.turkseker.gov.tr/?ModulID=3&MenuID=55

Figure 4.5 CO_2 emissions from lime production, 1990-2022



Methodological Issues:

The formula below is used to calculate emission from lime production.

$$CO_2\ emissions = (M_{ql} - M_{cl}) \cdot EF_{ql} + M_{dl} \cdot EF_{dl}$$

Where:

- CO_2 *emissions* = emissions of CO_2 from lime production, tonnes
- M_{ql} = Production of quick lime
- M_{cl}= Amount of captive lime (non emissive quick lime production)
- M_{dl}= Production of dolomitic lime
- EF_{ql} = Emission factor for quick lime
- EF_{dl}= Emission factor for dolomitic lime

In sugar industry, lime is produced for the purpose of refining sugar. Both quick lime and the CO_2 are utilized in precipitating impurities during the sugar production process. After examining the Turkish MRV system, no emission sources related to lime usage in the sugar industry were identified. Thus, it is assumed that all the CO_2 generated during lime production for sugar refining is fully captured, resulting in no CO_2 emissions. Similarly, in the soda ash production with solvay process, lime is produced and the resulting CO_2 is employed as an intermediate product within the process. It is assumed that all the CO_2 generated from limestone in the soda ash production is captured and resulting in no CO_2 emissions. Therefore, the lime produced for sugar industry and the soda ash production industry is deducted from the national lime production data and the emissions are calculated accordingly. Consistent with the Tier 1 method, Türkiye does not make corrections to estimated emissions to account for emissions from the production of hydrated lime or lime kiln dust.

Collection of activity data

Data on quick lime (CaO) production is collected from the Lime Producers Association (KISAD). KISAD gathers approximately 88% (as of 2015) of all the lime production data by requesting information from member production plants or searching for the activity reports from other producers. The remaining 12% is estimated by KISAD using the lime import and export data and related activity data in the industry. In addition, sector-specific lime consumption data is obtained from KISAD, allowing for the determination of captive lime (lime produced for the sugar industry and soda ash production). Dolomitic lime, mainly used in steel production, and its consumption data is collected from steel plants, assuming it represents the national dolomitic lime production data.

Table 4.5 Lime production and CO_2 emissions, 1990-2022

(kt)

Year	Quick Lime Production	Quick Lime produced for synthetic soda ash production	Quick Lime produced for sugar industry	Dolomitic lime production	County specific emission factor	CO_2 Emissions
1990	4 000	233	182	47	0.617	2 249
1995	4 090	334	140	64	0.638	2 357
2000	3 241	473	272	72	0.637	1 645
2005	3 584	506	224	106	0.646	1 925
2010	3 225	703	195	147	0.687	1 711
2011	3 819	747	301	171	0.685	2 031
2012	4 621	666	356	180	0.688	2 615
2013	4 400	715	300	174	0.695	2 486
2014	4 443	704	315	171	0.694	2 507
2015	4 325	683	313	158	0.693	2 429
2016	4 695	713	328	167	0.693	2 660
2017	4 868	863	342	189	0.693	2 684
2018	4 984	871	300	188	0.693	2 787
2019	4 750	917	320	169	0.693	2 565
2020	4 964	790	320	177	0.693	2 807
2021	5 024	940	340	203	0.693	2 751
2022	4 981	1 618	280	176	0.693	2 272

Choice of emission factor

Country specific emission factor is used for quick lime, while a default emission factor is used for dolomitic lime (0.77 tonnes CO_2 per tonne lime) from the 2006 IPCC Guidelines. For calculating the country specific emission factor of quick lime, factories are surveyed for their production volume and the CaO content of their product in 2016. By averaging on weight basis, the country specific CaO content of quick lime is calculated. Due to the stable trend in CaO content, this study did not iterated for the latest inventory, and the 2015 value was used for the 2016-2022 inventories.

Uncertainties and Time-Series Consistency:

There is uncertainty associated with not collecting data from each production plant but estimating amount of the production. Additionally, uncertainty arises from assuming that dolomitic lime production is equal to the consumption of dolomitic lime in the steel industry. An overall uncertainty of ±10% is estimated for the activity data. The uncertainty value for the EF is estimated to be ±2 % based on the 2006 IPCC Guidelines.

Source-Specific QA/QC and Verification:

Plant specific lime production data from KISAD is compared with data from the ILA (International Lime Association). The ILA report, based on the sales, demonstrates consistency with KISAD's data. ILA reports 4 800 kt of lime production in Türkiye, while KISAD reports 4 981 kt of lime production in Türkiye for 2022[5].

In addition, Türkiye's 8th five years' development plan released an annex special to building materials. One part of this report was allocated for the lime production in Türkiye and it includes historical lime production data for the years 1994-1998 which are align precisely with the lime production data for those years in the time series.

For the purpose of minimizing calculation errors, emission calculations were performed using two different software, and the results were compared. QA/QC procedures are implemented for each category to verify and improve the inventory under Türkiye's QA/QC plan.

Recalculations:

No recalculations have been made for this sector except for a rounding correction to the activity data for lime in 2016 and 2021.

Planned Improvement:

It is planned to calculate emissions using the MRV data provided by MoEUCC, in next submissions.

[5] https://www.internationallime.org/world-lime-production/

4.2.3 Glass production (Category 2.A.3)

Source Category Description:

A variety of raw materials are involved in glass production including limestone, dolomite and soda ash, which are primarily carbonates. These carbonates emit CO_2 when heated (calcined) during the glass production and these emissions are reported under 2.A.3 CRTcategory. Glass manufacturers also utilize a certain amount of recycled scrap glass (cullet), which reduces raw material consumption, resulting in cost and CO_2 emission reductions. During glass production, carbon-based fuels are burned to melt the glass batch, leading to the emission of CO_2, which is reported under the 1.A.2.f CRT category.

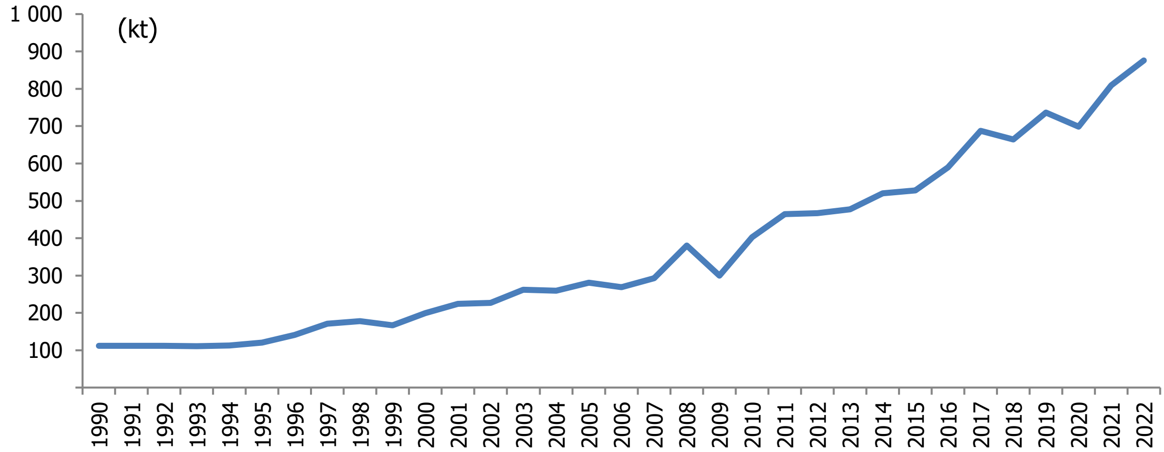
Turkish glass industry produces various type of glass with different chemical and physical properties. Türkiye's glass sector is divided into three main categories: container (household goods and bottles), float glass and fiber glass. Container and flat glass account for the majority of glass production throughout the entire time series.

The roots of the Turkish glass industry extend back to the establishment of Paşabahçe in 1935, initially boasting a modest production capacity of only 3 kilotons (kt). Over the years, this industry has undergone significant expansion and evolution. Despite lacking a distinct advantage in terms of raw material and energy costs compared to its European counterparts, the Turkish glass sector relies heavily on capacity utilization rates as a pivotal indicator of its competitive edge and profitability.

The industry demonstrated a remarkable growth trend either through capacity additions or through new product initiations between 1990 (1.13 Mt molten glass produced) and 2022 (5.1 Mt molten glass produced), increasing 354%.

The Figure 4.6 illustrates the trend in CO_2 emissions stemming from glass production. The data delineates a general upward trajectory in emissions, mirroring the concurrent rise in glass production within Turkey. Noteworthy fluctuations are observable, notably a significant downturn in emissions during 2009, attributed to the global economic recession that year.

Figure 4.6 CO_2 emissions from glass production, 1990-2022



Methodological Issues:

Estimation is based on the T3 method described in the 2006 IPCC Guidelines. Specifically, the calculation based on accounting for the carbonate input to the glass melting furnace

$$CO_2\ emissions = \sum_i (M_i \cdot EF_i \cdot F_i\ )$$

Where:

CO_2 emissions = emissions of CO_2 from glass production, tonnes
EF_i = emission factor for particular carbonate i,tonnes CO_2/tonne carbonate
M_i =weight or mass of the carbonate i consumed (mined), tones
Fi = fraction calcination achieved for the carbonate i, fraction

Collection of activity data

Türkiye produces float glass, container glass (including household glassware) and fiberglass for insulation. Total glass production of Türkiye is done by 8 companies. Activity data of molten glass production by glass type and carbonate input directly from the plants for all the years 1990-2022.

In the following table, total CO_2 emissions and glass production by type are given.

Table 4.6 Molten glass production and CO_2 emissions by type of glass, 1990-2022

(kt)

Year	Total Glass Production	Float Glass	Container (households +bottles)	Fiberglass	CO2 Emissions
1990	1 130	650	457	23	112
1995	1 292	625	645	22	120
2000	1 936	974	924	38	200
2005	2 178	1 016	1 088	74	281
2010	2 803	1 452	1 297	54	402
2011	3 171	1 746	1 350	75	465
2012	3 109	1 525	1 502	82	467
2013	3 189	1 624	1 488	77	477
2014	3 563	1 876	1 621	66	520
2015	3 448	1 661	1 721	65	528
2016	3 984	1 996	1 937	52	589
2017	4 379	2 305	2 026	48	688
2018	4 505	2 253	2 219	34	665
2019	4 510	2 102	2 343	66	736
2020	4 359	1 856	2 443	60	699
2021	4 847	2 152	2 621	75	809
2022	5 130	2 506	2 547	77	876

According to the figures in table above, glass production exhibited a steady increase by the year 2002, following the economic recession years of 1999-2001 in Türkiye (1 683kt in 1999 and 1 872 kt in 2002). The production experienced a decrease in 2009 (2 176 kt) due to the global economic recession. In 2020, total glass production slightly decreased, reaching 4 359 kt. By 2022, glass production had increased to 5 130 kt and it caused 876 kt of CO_2 emission. Compared to 2021, total emissions from glass production in 2022 witnessed an 8% increase.

Choice of emission factor

CO_2 emissions are calculated using the 2006 IPCC Guidelines Volume 3 default EFs for the carbonates (Table 2.1). The emission factors for each type of carbonate are given below.

Table 4.7 EFs for carbonates, 1990-2022

Carbonate	EF (tonnes CO_2/tonne carbonates)
Sodium carbonate or soda ash	0.41492
Limestone	0.43971
Dolomite	0.47732

Uncertainties and Time-Series Consistency:

Due to emissions from glass production being estimated based on the carbonate input (Tier 3), the uncertainty in emission factor is relatively low due to their reliance on stoichiometric ratio. There may be some uncertainty associated with assuming that there is 100 percent calcination of the carbonate input (1%). Emission factor uncertainty is assumed as 3%, while the emission factor for activity data is also assumed %3 under the Tier 3 approach.

Source-Specific QA/QC and Verification:

The data used in Glass Production category is directly collected from these plants via questionaire for all years from 1990 to 2022.

To minimize calculation errors in this submission, emission calculations were performed using two different software programs, and the results were compared.

QA/QC procedures are implemented for each category to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculation:

The inclusion of data from two plants resulted in an average increase of 0.8 kt CO_2 between the years 1990-2021.

Planned Improvements:

The minor CO_2 emitting raw materials used in the production of molten glass, such as barium carbonate, bone ash, and potassium carbonate, will be included in the calculations following the examination of the MRV data provided by MoEUCC.

4.2.4 Other process uses of carbonates (Category 2.A.4)

The category "other process uses of carbonates", is a key category. In this category, emissions from ceramics, bricks and roof tile production, other uses of soda ash and non-metallurgical magnesia production are reported.

Figure 4.7 Share of CO_2 emissions from other uses of carbonates, 1990-2022

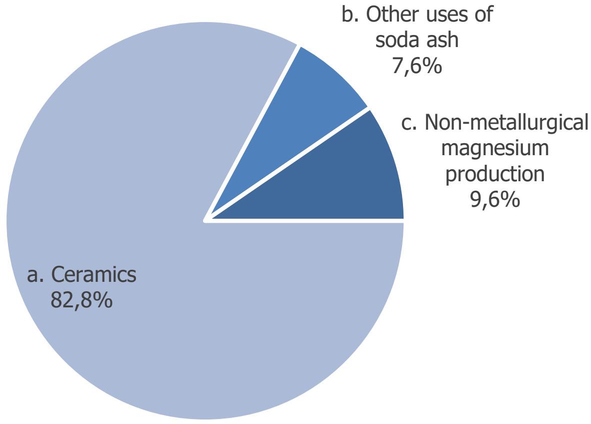


Figure 4.7 shows the distribution of CO_2 emissions in other uses of carbonates for 2022. Ceramics production emerges as the dominant sector, accounting for 82.8% (2 365 kt) of CO_2 emissions in other uses of carbonates. Non-metallurgical magnesium production follows with a share of 9.6% (273.3 kt), while the "other uses of soda ash" sector contributes 7.6% (216.6 kt) to CO_2 emissions in this category.

4.2.4.1 Ceramics (Category 2.A.4.a)

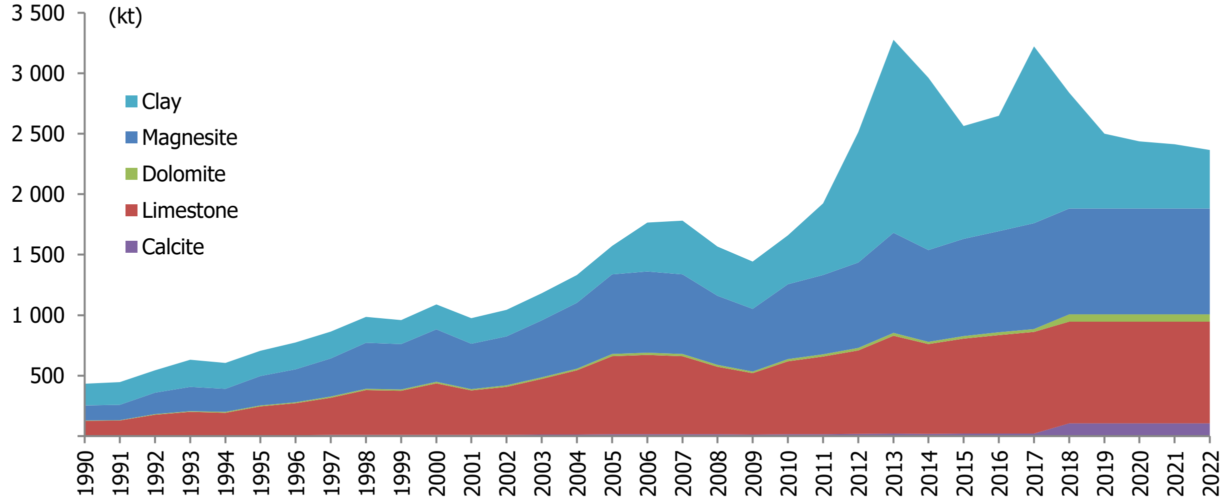
Source Category Description:

Ceramics production is a significant source of CO_2 emissions, primarily due to the calcination of raw materials such as limestone and magnesite during manufacturing. Additionally, the production process is highly energy-intensive, particularly the heating of ceramics to high temperatures for calcination, which consumes a considerable amount of energy. The majority of ceramic manufacturers in Türkiye utilize natural gas for this purpose. The emissions resulting from the combustion of fuels to heat ceramics are categorized under 1.A.2.f CRT category.

Ceramics include the production of vitrified clay pipes, refractory products, expanded clay products, wall and floor tiles, tableware, ornamental ware, sanitary ware, bricks and tile.

CO_2 emissions from ceramic production show an increasing trend from 1990 to 2017. In 2022, ceramic production and the resulting CO_2 emissions decreased by 26.6% with respect to 2017.

Figure 4.8 CO_2 emissions, by raw materials type, from ceramics, 1990-2022



Methodological Issues:

The T2 method is used to estimate emissions from the ceramics industry. The method requires consumption data for each of the raw materials consumed, and multiplying by the respective emission factor for the carbonate to estimate CO_2 emissions.

$$CO_2\ emission = \sum (M_i \cdot EF_i)$$

Where:

CO_2 emissions = emissions of $CO_2$from other process uses of carbonates, tonnes
M_i = mass of limestone or dolomite respectively (consumption), tonnes.
EF_i = emission factor for carbonate calcination, tonnes CO_2/tonne carbonate

Collection of activity data

Calcite, limestone, dolomite, magnesite and hydro-magnesite are consumed as raw materials in the ceramics industry. Production of ceramic tile and sanitary ware and carbonate consumption data (refer to the following table) are gathered from the Turkish Ceramics Federation for the time series 1990-2018. The amount of bricks and tile are gathered by Turkish Statistical Institute for the years 1990-1999 and 2005-2022. Data gaps for the years 2000-2004 are estimated. In this calculation following assumptions are made by using one of the plant data;

$$1\ m^3\ brick = 600\ kg,$$
$$1\ brick = 4\ kg,$$

$$1 \text{ tile} = 3 \text{ kg},$$
$$\text{Kg}_{\text{ clay}} = 1.3{*}\text{kg}_{\text{ bricks and tile}}$$

Table 4.8 Raw material consumption and production, 1990-2022

	Raw Material (kt)				Product (kt)				Total Product (kt)
	Calcite	Limestone	Dolomit	Magnesite-hydro magnesite	Clay	Ceramic Tile	Sanitary ware	Bricks and Tile	
1990	7	278	7	240	5 832	884	47	4 486	5 417
1995	15	544	15	469	6 712	1 819	78	5 163	7 060
2000	25	968	25	834	6 675	2 975	114	5 135	8 224
2005	37	1464	37	1 262	7 685	4 437	237	5 911	10 585
2010	35	1373	35	1 184	13 211	4 165	220	10 162	14 547
2011	37	1458	37	1 257	19 296	4 420	245	14 843	19 508
2012	40	1572	40	1 355	35 064	4 760	260	26 972	31 992
2013	47	1842	47	1 588	51 828	5 610	270	39 868	45 748
2014	43	1685	43	1 453	46 289	5 100	280	35 607	40 987
2015	46	1786	46	1 540	30 327	5 280	300	23 329	28 909
2016	47	1854	47	1 598	31 069	5 610	310	23 899	29 819
2017	49	1912	49	1 675	47 482	5 755	352	36 525	42 632
2018	241	1912	127	1 675	31 109	6 030	350	23 930	30 310
2019	241	1 912	127	1 675	20 091	6 030	350	15 454	21 834
2020	241	1 912	127	1 675	18 051	6 030	350	13 885	20 265
2021	241	1 912	127	1 675	17 282	6 030	350	13 294	19 674
2022	241	1 912	127	1 675	15 704	6 030	350	12 080	18 460

Choice of emission factor

Default EFs provided in table 2.1 of the 2006 IPCC Guidelines are applied to the total raw material consumption for the entire time series to estimate emissions. The following table shows the default emission factors used in the calculations. EF for clay is calculated by using 7% CS carbon content of clay and default emission factor of calcite and limestone. To determine the average carbon content in clay, 11 plants were asked their raw material analysis result. This reveal that average carbon content in clay is around 7%.

Table 4.9 Carbonate EFs for all years in the time series

Carbonate	EF (tonnes CO_2/ton carbonate)
Calcite and limestone	0.43971
Dolomite	0.47732
Magnesite	0.52197
Clay	0.03077

Source: Table 2.1 of the 2006 IPCC Guidelines, Vol. 3

CO_2 emissions from each raw material are given in the table below and in Figure 4.8.

Table 4.10 CO_2 emissions from raw material consumption, 1990-2022

(kt)

Year	Calcite	Limestone	Dolomite	Magnesite	Clay	Total
1990	3.3	122.2	3.6	125.1	179.5	433.7
1995	6.7	239.1	7.2	244.7	206.6	704.4
2000	10.9	425.4	11.8	435.4	205.5	1 088.9
2005	16.4	643.6	17.8	658.7	236.5	1 573.1
2010	15.4	603.9	16.7	618.0	406.6	1 660.7
2011	16.4	641.0	17.8	656.0	593.9	1 925.1
2012	17.7	691.3	19.2	707.5	1079.3	2 514.9
2013	20.7	809.8	22.5	828.7	1595.3	3 276.9
2014	18.9	740.9	20.5	758.2	1424.7	2 963.4
2015	20.1	785.4	21.8	803.7	933.5	2 564.4
2016	20.8	815.3	22.6	834.3	956.3	2 649.3
2017	21.5	840.7	23.3	874.3	1461.5	3 221.3
2018	106.1	840.7	60.6	874.3	957.5	2 839.2
2019	106.1	840.7	60.6	874.3	618.4	2 500.1
2020	106.1	840.7	60.6	874.3	555.6	2 437.3
2021	106.1	840.7	60.6	874.3	531.9	2 413.6
2022	106.1	840.7	60.6	874.3	483.4	2 365.1

Uncertainties and Time-Series Consistency:

As the EF represents the stoichiometric ratio indicating the amount of CO_2 released during the calcination of carbonate, the EF uncertainty in this category is relatively low. There is some uncertainty associated with assuming a fractional purity of limestone and dolomite in cases where only carbonate rock data are available (±1-5%).

AD uncertainties are greater than the uncertainties associated with EFs. Although there is a significant amount of roof tiles and bricks production in Türkiye, unfortunately there is no verified activity data for this type of production. Only ceramic tiles and sanitary ware productions were taken into account. Therefore, for this category AD uncertainty is considered as 30% while the EF uncertainty is considered 2% which is in line with the 2006 IPCC Guidelines, Volume 3 (page 2.39).

Source-Specific QA/QC and Verification:

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculations

Due to the updated total bricks and tiles production data in the PRODCOM database, emissions from the ceramics category decreased by 14.7 kt CO2 in 2020 and by 9.7 kt CO2 in 2021.

Planned Improvements

Ceramic production data were gathered from Turkish Ceramics Federation until the federation had judicial issues regarding data collection from its members in 2020. As a result of this situation, TurkStat launched studies for estimating emissions of ceramics sector from other data sources. It is planned to calculate emissions using the MRV data and these calculations will be examined in future submissions.

4.2.4.2 Other uses of soda ash (Category 2.A.4.b)

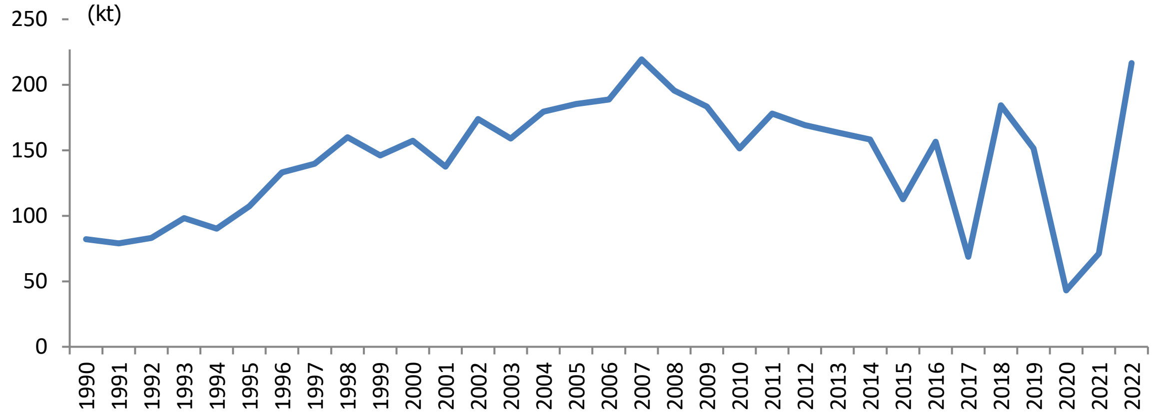
Source Category Description:

In this category, emissions from soda ash consumption are considered. CO_2 emissions resulting from soda ash used in glass manufacturing industry are included in Glass Production. There are no other uses of soda ash included elsewhere in the Turkish Inventory.

Soda ash serves as an important intermediate product primarily for the glass industry and detergent industry, with applications in various other sectors. Between 1990 (315 kt) and 2022 (1 1472 kt), soda ash consumption experienced a significant increase alongside the growth of the Turkish industry. However, notable decreases in consumption occurred during the economic recessions of 2001 and 2008. Since 2010, consumption has rebounded, driven by the expansion of the glass industry and the broader Turkish industrial growth.

In 2022 the GHG emissions resulting from the apparent consumption of soda ash amounted to 217 kt of CO_2.

Figure 4.9 CO_2 emissions from other use of soda ash, 1990-2022



Methodological Issues:

Türkiye does not collect annual statistics on soda ash consumption by industry; instead, the apparent consumption of soda ash is calculated by adding imports data to production data and then subtracting exports and usage in the glass sector. This methodology assumes that all apparent consumption of soda ash is emissive.

Collection of activity data

Apparent consumption is calculated by the following formula.

$$\textit{Total Consumption} = \textit{Soda ash production} + \textit{Imports} - \textit{Exports}$$

$$\textit{Apparent Consumption} = \textit{Total Consumption} - \textit{Use in Glass Industry}$$

Total production values are gathered from the two soda ash producer plants, while foreign trade statistics are provided by TurkStat. The data for the amount of soda ash used in the glass sector is estimated from glass producer plants.

Choice of emission factor

The default EF (0.41492 tonnes CO_2 /tonnes product) taken from Table 2.1 of the 2006 IPCC Guidelines, Volume 3, Chapter 2 is applied for the full time series.

Total consumption, use in glass industry, apparent consumption and CO_2 emissions from soda ash consumption are given in the following table.

Table 4.11 Activity data for the other use of soda ash and CO_2 emissions, 1990-2022 (kt)

Year	Total Consumption	Use in Glass Industry	Apparent Consumption	CO_2 Emissions
1990	315	117	198	82
1995	385	126	259	107
2000	601	222	379	157
2005	749	302	447	185
2010	807	442	365	151
2011	939	510	429	178
2012	918	511	408	169
2013	915	521	394	164
2014	944	562	382	158
2015	897	626	271	113
2016	1 017	639	377	157
2017	914	748	165	69
2018	1 180	736	444	184
2019	1 168	803	365	152
2020	848	744	104	43
2021	1 050	878	172	71
2022	1 472	950	522	217

Uncertainties and Time-Series Consistency:

The uncertainty associated with AD for this source is considered to be ±10% due to the utilization of national statistics and a general apparent consumption calculation formula. Because a default EF based on stoichiometry is used for the emission calculation, the uncertainty for the EF is defined as ±2%.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

There are three plants in Türkiye producing soda ash. The production data these plants and Turkish soda ash export data are compared, and the data are found to be consistent.

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

Recalculations:

The inclusion of data from two new glass producers in the calculations led to a recalculation of emissions from other uses of soda ash, resulting in an average decrease of 0.5 kt CO2 per year between 1990 and 2021.

Planned Improvements:

No further improvements are planned regarding this source.

4.2.4.3 Non metallurgical magnesia production (Category 2.A.4.c)

Source Category Description:

This source category should include emissions from magnesia (MgO) production that are not accounted for elsewhere. Magnesite ($MgCO_3$) is one of the key inputs into the production of magnesia, and ultimately fused magnesia. There are three major categories of magnesia products: calcined magnesia, dead burned magnesia (periclase), and fused magnesia. Calcined magnesia finds applications in various fields such as agricultur and industry (e.g., feed supplements to cattle, fertilizers, electrical insulation, and flue gas desulphurisation). Dead burned magnesia is predominantly used in refractory applications, while fused magnesia serves the refractory and electrical insulating markets.

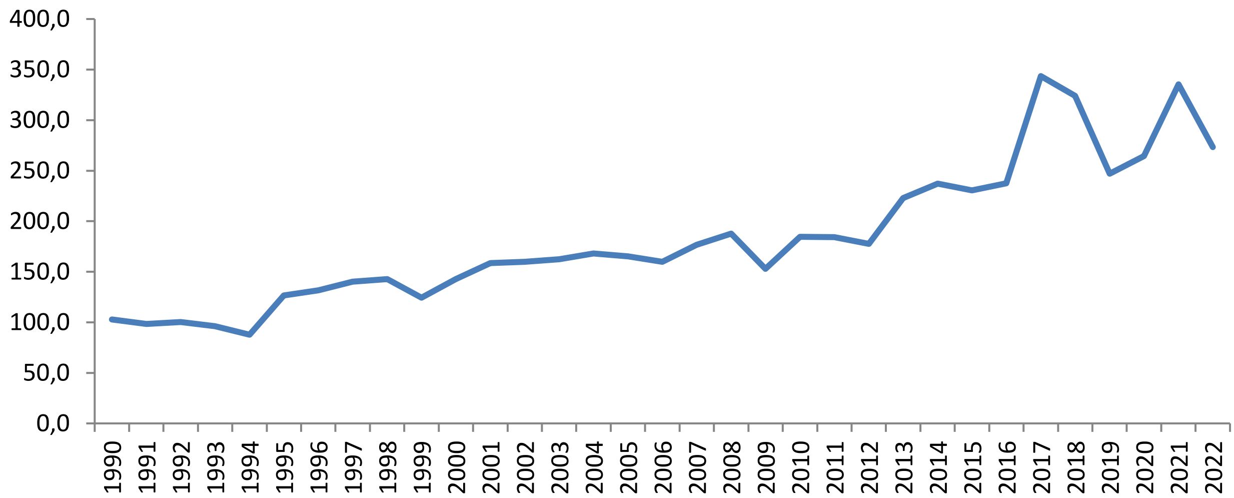
Magnesia (MgO) is produced by calcining magnesite ($MgCO_3$) which results in the release of CO_2 as shown in the chemical reaction below;

$$MgCO_3 \rightarrow MgO + CO_2$$

The production process determines whether calcined magnesia or dead burned magnesia is produced, with dead burned magnesia requiring higher temperatures and boasting higher purity in terms of MgO content. Fused magnesia, the purest form, is manufactured in electrical arc furnaces at extremely high temperatures.

The figure below illustrates the CO_2 emissions from total magnesia production between 1990 and 2022.

Figure 4.10 CO_2 emissions from magnesia production, 1990-2022



Methodological Issues:

Türkiye implements Tier 1 method. CO_2 emissions are calculated by using magnesia production (calcined production + deadburned magnesia) as AD and multiplied by the default IPCC EF. There is no significant amount of fused magnesia production in Türkiye.

Collection of Activity Data

The magnesia production data are collected from magnesia producers. There are seven plants in Türkiye producing magnesia. Each of them were asked to provide their activity data via questionnaire.

Choice of Emission Factor

The default IPCC EF (0.52197 tonnes CO_2 / tonne carbonate) taken from Table 2.1 of the 2006 IPCC Guidelines, Volume 3, Chapter 2, is applied for all the time series.

Table 4.12 Magnesia production and CO_2 emissions, 1990-2022

(kt)

Year	Magnesia production	CO_2 Emissions
1990	196.8	102.7
1995	242.5	126.6
2000	273.7	142.8
2005	316.6	165.3
2010	353.7	184.6
2011	353.2	184.4
2012	340.3	177.6
2013	426.8	222.8
2014	454.1	237.0
2015	441.4	230.4
2016	455.1	237.6
2017	658.1	343.5
2018	621.0	324.1
2019	473.1	247.0
2020	506.5	264.4
2021	642.3	335.3
2022	523.5	273.3

Uncertainties and Time-Series Consistency:

AD is collected from the companies, and all seven major producers are surveyed for their activity data. Therefore, the uncertainty associated with activity data is 10%. Because the IPCC default EF is used for the emissions calculation, the uncertainty for the EF is defined as ±2%.

Source-Specific QA/QC and Verification:

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculation:

No recalculations have been made to emissions from this category.

Planned improvement:

No further improvements are planned regarding this source.

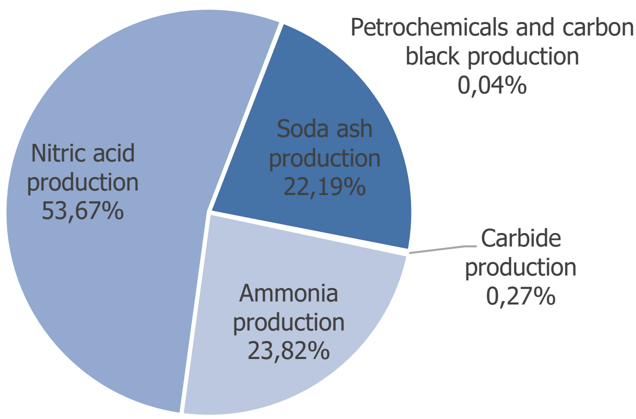
4.3 Chemical Industry (Category 2.B)

In 2022, the chemical industry was responsible for 4.2% of the total carbon dioxide equivalent emissions from the industrial processes and product use sector. Between 1990 (1 511 kt CO_2 eq) and 2022 (2 944 kt CO_2 eq.), total carbon equivalent emissions increased by 94.8%. The increase in emissions is driven exclusively by the increase in CO_2 emissions from ammonia production, soda ash production, and N_2O emissions from nitric acid production.

Figure 4.11 depicts the share of CO_2 equivalent emissions from chemical industry. The CO_2 eq. emissions from nitric acid production account for 53.7%, followed by ammonia production (23.8%) and soda ash production (22.2%). Carbide use and petrochemical production are much smaller contributors to emissions (0.27% and 0.04%, respectively).

There is no production of adipic acid, caprolactam, glyoxal, glyoxylic acid, or titanium dioxide produced in Türkiye, therefore emissions are reported as "NO" for these subcategories.

Figure 4.11 Share of CO_2 eq. emissions from chemical industry, 2022



4.3.1 Ammonia production (Category 2.B.1)

Source Category Description:

Ammonia is a major industrial chemical and the most important nitrogenous material produced. Ammonia gas finds application directly as a fertilizer, in heat treating, paper pulping, nitric acid and nitrates manufacture, nitric acid ester and nitro compound manufacture, explosives of various types, and as a refrigerant. Amines, amides, and various other organic compounds, such as urea, are synthesized from ammonia.

Natural gas is used as the feedstock for ammonia production in Turkish production plants. CO_2 is formed during reforming of natural gas for obtaining hydrogen, which is then reacted with nitrogen to synthesis ammonia. The overall reforming reaction and ammonia synthesis reactions are given below.

Overall reforming reaction:

$$0.88CH_4 + 1.26\,Air + 1.24\,H_2O \rightarrow 0.88CO_2 + N_2 + 3H_2$$

Ammonia synthesis reaction:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

Ammonia production necessitates the combustion of fuels to meet the energy demands of the process. Besides serving as a feedstock, natural gas is also utilized to meet the energy requirement of the process. Both the emissions from the ammonia production process and the combustion of fuels for energy demand are included in the 2.B.1 CRTcategory. To prevent double counting, the total quantities of natural gas used in ammonia production are subtracted from the quantity reported under energy use in the energy sector.

IGSAS is one of three ammonia plants in Türkiye, commencing its operation in 1977. In 1993, second ammonia plant, Gemlik Gubre, and in 2020 third ammonia plant, ETI Gubre began operations. IGSAS also produces urea using CO_2 gas as a feedstock. CO_2 is separated from the synthesis gas in the decarbonising step within the ammonia production process. Subsequently, some of the CO_2 gas is utilized in the urea production process, while the remaining gas is released to atmosphere. The chemical reaction that produces urea is:

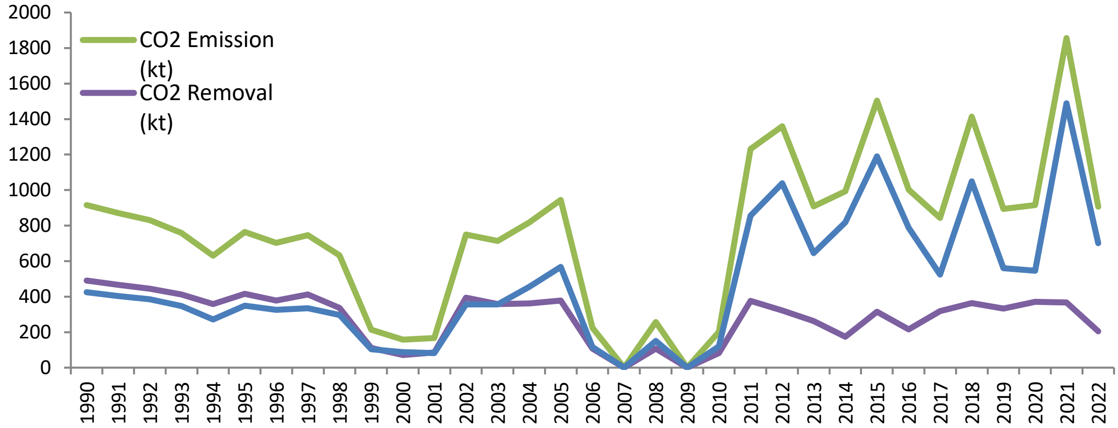
$$2NH_3 + CO_2 \rightarrow NH_3COONH_4 \rightarrow CO\,(NH_2)_2 + H_2O$$

The Figure 4.12 shows the CO_2 emissions from ammonia production as well as the amount of CO_2 recovered.

Overall, between 1990 (425 kt CO_2 eq.) and 2022 (701 kt CO_2 eq.), emissions from ammonia production increased by 65%. Large inter-annual changes in CO_2 emissions from ammonia production are observed, with rapid increases in emissions can be seen shortly after periods of economic downturns.

In Türkiye; due to economic factors, there was no ammonia production in 2007 and 2009 as shown in the figure below. During these two years, ammonia was imported to meet domestic demand.

Figure 4.12 CO_2 emissions and removals from ammonia production, 1990-2022



Methodological Issues:

All three ammonia production plants in Türkiye use natural gas as feedstock. Tier 2 method is employed in accordance with the 2006 IPCC Guidelines. Initially, the total fuel requirement (both as feedstock and as combusted fuel for energy demand) is estimated by determining the total quantity of ammonia produced and the fuel requirement per unit of output. In order to calculate CO_2 emissions; the total fuel requirement is multiplied by the country-specific carbon content and the carbon oxidation factor.

$$TFR = \sum_j (AP_j \cdot FR_j)$$

Where:

TFR= total natural gas requirement, GJ

AP_j = ammonia production using natural gas in process type j, tonnes

FR_j = fuel requirement per unit of output in process type j, GJ/tonne ammonia produced

$$E_{CO2} = \sum (TFR \cdot CCF \cdot COF \cdot 44/12) - R_{CO2}$$

Where:

E_{CO2} = emissions of CO_2, kg

TFR= total fuel requirement for natural gas, GJ

CCF= carbon content factor of natural gas, kg C/GJ

COF= carbon oxidation factor of natural gas, fraction

R_{CO2} = CO_2 recovered for downstream use (urea production), kg

Collection of activity data

Ammonia production and fuel requirement data are obtained from producers on an annual basis. The survey on ammonia production is sent to the producer companies every year. The producers report that ammonia production and natural gas consumption data are measured by on-line flow meters in the process, whereas urea production data is calculated from the raw material consumption.

Due to the confidentiality of activity data, production data are given as 1990=100, and all years are reported relative to ammonia production in 1990.

The total amount of urea produced in ammonia plants is shown in the following table, where the urea production data and the ammonia production data are given with respect to 1990=100 by years. Thus, one can compare the urea production and the ammonia production by years. Türkiye assumes that 0.733 tonnes of CO_2 are required per tonne of urea produced. This value is taken from the 2006 IPCC Guidelines.

Table 4.13 Ammonia production and CO_2 emissions, 1990-2022

Year	Ammonia Production (1990=100)	Urea Production (1990=100)	CO_2 Emission (kt)	CO_2 Removal (kt)	Net CO_2 Emission (kt)
1990	100	100	915	491	425
1995	82	85	764	415	348
2000	15	14	158	70	88
2005	104	77	945	378	567
2010	21	17	201	82	119
2011	122	77	1 232	376	856
2012	142	65	1 360	321	1039
2013	97	54	908	263	645
2014	107	35	993	174	818
2015	157	64	1 503	314	1190
2016	105	44	1 002	215	787
2017	82	65	844	319	525
2018	150	74	1 413	364	1050
2019	97	68	893	333	560
2020	97	76	916	371	545
2021	183	75	1 856	367	1489
2022	122	42	906	205	701

Choice of emission factor

Türkiye applies the carbon content of natural gas and an oxidation factor to the total fuel requirement to estimate emissions. The carbon content of the natural gas is provided by BOTAS (Petroleum Pipeline Corporation), and it is the same as that used in the energy sector.

Uncertainties and Time-Series Consistency:

Because a country specific EF is used for the calculation of emissions from ammonia production, uncertainty is taken as ±5%. Consistent with the 2006 IPCC Guidelines, due to the use of plant specific activity data, the uncertainty value for AD is considered as ±2%.

Source-Specific QA/QC and Verification:

There are three ammonia producers in the Turkish market. All producers utilize natural gas to produce ammonia and employ the same process. Hence, their implied emission factors are comparable. Upon comparison, they are found to be consistent. Furthermore, total ammonia production data of Türkiye obtained from the producers is cross-checked with data from PRODCOM every year.

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculation:

There is no source specific recalculation for this submission.

Planned Improvement

No further improvements are planned regarding this source.

4.3.1 Nitric acid production (Category 2.B.2)

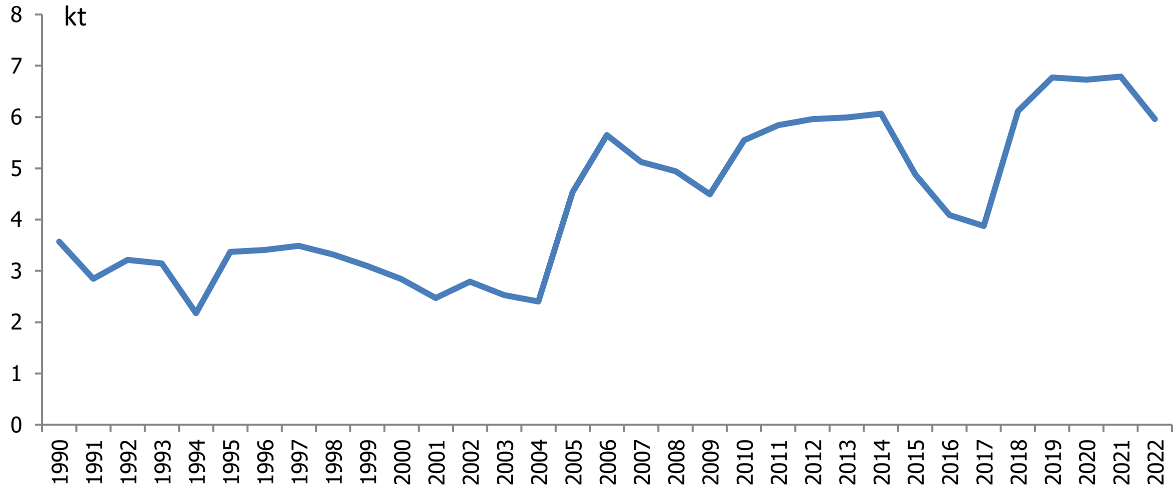
Source Category Description:

Nitrous oxide (N_2O) is emitted during the production of nitric acid, which serves as a raw material primarily in the manufacturing of nitrogenous-based fertilizers. Nitric acid is also used in the production of explosives, for metal etching, and in the processing of ferrous metals.

In Türkiye; there are four nitric acid plants: IGSAS, operational since 1961; Toros Tarım, operational since 1972; Gemlik Gubre, operational since 2006; and BAGFAS, operational since 2015. These plants operate medium-pressure combustion, with some indicating the use of a selective catalytic reduction system.

N_2O emissions were relatively stable between 1990 (3.6 kt N_2O) and 2004 (2.4 kt N_2O). However, emissions from nitric acid production exhibited instablity between 2005 and 2009, as depicted in Figure 4.13, attributed to the commencement of production at a new nitric acid plant in 2006. Additionally, one of the nitric acid plants began employing an abatement technology in 2008, resulting in a decrease in its emission factor. N_2O emissions reached 5.96 kt N_2O in 2022. In 2016 and 2017, N_2O emissions were 4.1 kt and 3.9 kt, respectively, significantly lower than in 2014 due to a dramatic decrease in production at one major capacity nitric acid plant.

Figure 4.13 N_2O emissions from nitric acid productions, 1990-2022



Methodological Issues:

N_2O emissions from nitric acid production are not a key category in Türkiye. N_2O emissions are calculated using the T1 method outlined in the 2006 IPCC Guidelines. Total nitric acid production is multiplied by an emission factor as shown below.

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

Where:

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

Collection of activity data

Nitric acid production data were obtained from plants via questionnaires sent annually. Operators provide production data for 100% concentration HNO_3. Quantities are determined using flow meters measuring the nitric acid production flow through pipelines, with a totalizer summing up to provide annual production data.

Choice of emission factor

There are four nitric acid production plants, IGSAS, Toros Tarım, Gemlik Gubre and BAGFAS. Emission factors are determined according to their usage of abatement technology and its efficiency. However, the emission factors for each plant and the total nitric acid production cannot be disclosed due to confidentiality reasons between the years 1990 and 2015. Total nitric acid production is given in the table below.

Table 4.14 Nitric acid production and N_2O emissions, 1990-2022

Year	Nitric acid production	Total N_2O emission (kt)
1990	C	3.57
1995	C	3.37
2000	C	2.84
2005	C	4.54
2010	C	5.55
2011	C	5.84
2012	C	5.96
2013	C	5.99
2014	C	6.07
2015	863	4.88
2016	771	4.09
2017	778	3.88
2018	1 066	6.12
2019	1 303	6.77
2020	1 300	6.73
2021	1 349	6.79
2022	1 164	5.96

Uncertainties and Time-Series Consistency:

The 2006 IPCC Guidelines recommended default uncertainty value of ± 20% is used for the EF, consistent with the value in Table 3.3 for medium pressure combustion plants.

Türkiye applies the default IPCC uncertainty value for AD uncertainty of ± 2%, which is in line with the 2006 IPCC Guidelines Volume 3 (page 3.25).

Source-Specific QA/QC and Verification:

Plant specific nitric acid production data collected from the plants via an annual questionnaire for inventory calculations are compared with TurkStat PRODCOM, Turkish national industrial production statistics and, found to be consistent. In accordance with monitoring, reporting, and verifying regulations, nitric acid plants are required to report their emissions to the Ministry of Environment, Urbanization, and Climate Change by measuring their emissions with N_2O gas monitoring devices. Calculated and reported emissions are compared.

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculation:

There is no source specific recalculation for this submission.

Planned Improvements:

No further improvement are planned regarding this source.

4.3.3. Adipic acid production (Category 2.B.3)

There is no adipic acid production in Türkiye during the period 1990-2022.

4.3.4. Caprolactam, glyoxal and glyoxylic acid production (Category 2.B.4)

There is no caprolactam, glyoxal and glyoxylic acid production in Türkiye during the period 1990-2022.

4.3.5. Carbide production (Category 2.B.5)

Source Category Description:

The production of carbide can lead to emissions of CO_2, CH_4, CO, and SO_2. Silicon carbide serves as a significant artificial abrasive and is derived from silica sand or quartz and petroleum coke. Calcium carbide is used in the production of acetylene and serves as a reductant in electric arc furnaces. Acetylene is used for welding applications, thus contributing to emissions which are accounted for the IPPU sector.

Calcium carbide is produced by the reaction of metallurgical coke and lime under electric arc according to the reaction given below.

$$CaO + 3C \rightarrow CaC_2 + CO\ (+ \tfrac{1}{2}\, O_2 \rightarrow CO_2)$$

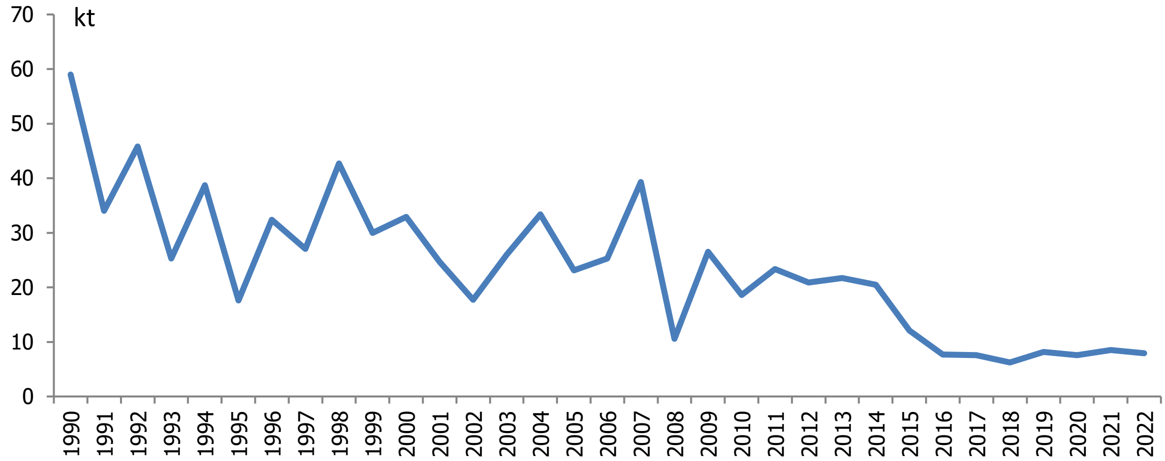
In Türkiye, calcium carbide is used either as a reductant in the steel making process or the feedstock for acetylene production. Subsequently, acetylene is used as fuel in the welding applications. The combustion of acetylene in welding applications give emissions according to the reaction given below and it is accounted in IPPU sector.

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2\ (+ 2.5\ O_2 \rightarrow 2CO_2 + H_2O)$$

In Türkiye there is no silicon carbide production. Calcium carbide has been produced in Türkiye till 2015. The amount of coke used is deducted from the Energy part of the NID to avoid double count.

CO_2 emissions from calcium carbide production and utilization of carbide in acetylene was 59 kt CO_2 in 1990. Year by year carbide production decreased and in 2015 the carbide production and usage of carbide in acetylene production emissions was 12.1 kt CO_2. Finally, in 2016 the production line of carbide was closed due to economic reasons. And use of carbide in acetylene continued and resulted 7.9 kt CO_2 emissions in 2022.

Figure 4.14 CO_2 emissions from carbide production, 1990-2022



Methodological Issues:

Carbide production is not a key category. Calcium carbide was produced in Türkiye by a single plant till 2015 and then the production line was closed. The calculation of emissions is based on plant-specific data.

$$E_{CO2} = AD \bullet EF$$

Where:

E_{CO2} = emissions of carbon dioxide
AD = activity data on carbide production
EF = CO_2 emission factor.

The use of calcium carbide also leads to the emissions and it is calculated by the Tier 1 methodology suggested in the guideline. The amount calcium carbide used is multiplied with the proper emission factor suggested in the guideline.

Collection of activity data

The calcium carbide production period of a single plant which finalize its production in 2015, the calcium carbide production data was directly obtained from the producer on an annual basis by a questionnaire.

Both amount of carbide produced and amount of raw material used as metallurgical coke data were obtained. However, emissions were calculated by using the carbide production data.

Confidential production data are provided relative to 1990, along with CO_2 emissions from calcium carbide production as can be seen in the table below.

Table 4.15 Calcium carbide production and CO_2 emissions, 1990-2022

Years	Calcium Carpide Production (1990=100)	Calcium carpide use (kt)	CO_2 Emissions from carbide production (kt)	CO_2 Emissions (kt)
1990	100.0	15.9	41.5	59.0
1995	24.2	6.9	10.0	17.6
2000	43.3	13.6	18.0	32.9
2005	27.1	10.8	11.2	23.1
2010	19.8	9.4	8.2	18.6
2011	28.0	10.7	11.6	23.4
2012	28.8	8.1	11.9	20.9
2013	27.5	9.4	11.4	21.7
2014	25.4	9.0	10.5	20.5
2015	13.9	5.7	5.8	12.1
2016	0.0	7.0	0.0	7.7
2017	0.0	6.9	0.0	7.6
2018	0.0	5.7	0.0	6.2
2019	0.0	7.4	0.0	8.2
2020	0.0	6.9	0.0	7.5
2021	0.0	7.7	0.0	8.5
2022	0.0	7.2	0.0	7.9

Choice of emission factor

Due to confidentiality the emission factor of the carbide production cannot be revealed.

Uncertainties and Time-Series Consistency:

The greatest contributor to the uncertainty is that the assumption made upon all of the carbide is used for producing acetylene gas. Depending on the expert judgement the uncertainty value of the EF is taken as ±20%, while the default uncertainty value of the activity data is taken as 5%, in line with the 2006 IPCC Guidelines (Volume 3 Page 3.45).

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category to verify and enhance the inventory under the QA/QC plan of Türkiye.

Plant-specific production data are compared with national statistics available from PRODCOM (National Industrial Production Statistics) and found to be consistent.

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

Recalculation:

There is no source specific recalculation for this submission.

Planned Improvements

No further improvements are planned regarding this source.

4.3.6. Titanium dioxide production (Category 2.B.6)

There is no titanium dioxide production in Türkiye during the period 1990-2022.

4.3.7. Soda ash production (Category 2.B.7)

Source Category Description:

Soda ash (sodium carbonate, Na_2CO_3) is a white crystalline solid that is used as a raw material in a large number of industries including glass manufacture, soap and detergents, pulp and paper production and water treatment. CO_2 is emitted from the use of soda ash and these emissions are accounted for as a source under the relevant using industry as discussed in Volume 3, Chapter 2 in the 2006 IPCC Guidelines. CO_2 is also emitted during production of soda ash, with the quantity emitted dependent on the industrial process used to manufacture soda ash.

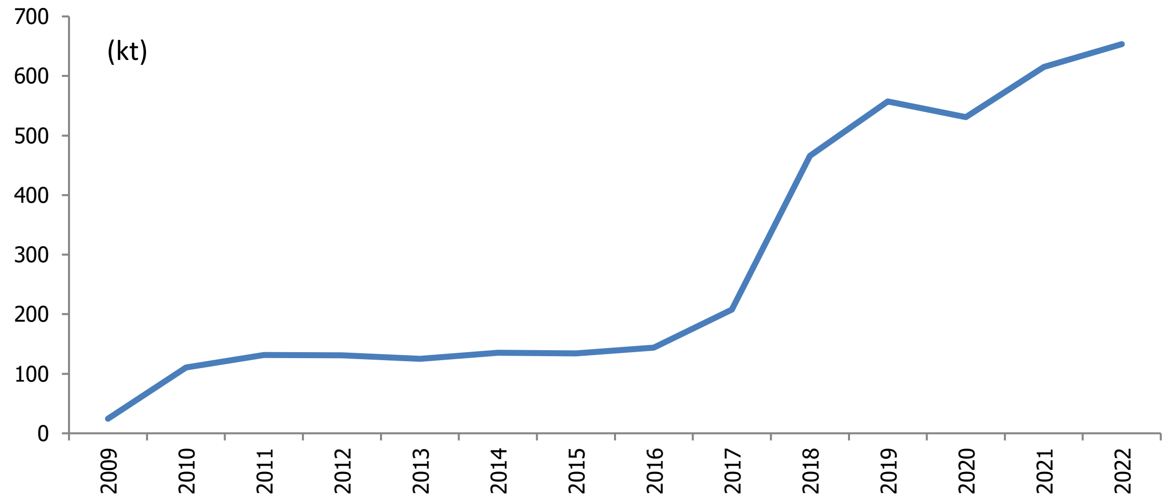
Emissions of CO_2 from the production of soda ash vary substantially with the manufacturing process. Four different processes may be used commercially to produce soda ash. Three of these processes, monohydrate, sodium sesquicarbonate (trona) and direct carbonation, are referred to as natural processes. The fourth, the Solvay process, is classified as a synthetic process. Calcium carbonate (limestone) is used as a source of CO_2 in the Solvay process.

There are three soda ash plants in Türkiye. One of these plants produces soda ash by utilizing trona and began operation in 2009, while the other produce synthetic soda ash (solvay process) and began operation in 1969. Third one started production in 2018.

In the Solvay process, sodium chloride brine, limestone, metallurgical coke and ammonia are the raw materials used in a series of reactions leading to the production of soda ash. Ammonia, however, is recycled and only a small amount is lost. From the series of reactions CO_2 is generated during calcination of limestone. The generated CO_2 is captured, compressed and directed to Solvay precipitating towers for consumption in a mixture of brine (aqueous NaCl) and ammonia. Although CO_2 is generated as a by-product, the CO_2 is recovered and recycled for use in the carbonation stage and in theory the process is neutral, i.e., CO_2 generation equals uptake.

Soda ash production by utilizing trona started in 2009 while emissions from soda ash production using the solvay process are not estimated due to the carbon neutral characteristic of the process. Therefore; for the years 1990-2008, emissive soda ash production is reported as not occurring. In the figure below you can see the trend of the CO_2 emissions from soda ash productions. In the year 2009 a small amount of CO_2 emitted due to plant was not working full capacity due to start up. In 2022 emissions from soda ash increased by 6.2% with respect to previous year and it was 653 kt of CO_2.

Figure 4.15 CO_2 Emissions from soda ash production 2009-2022



Methodological Issues:

The natural production process of soda ash results in CO_2 emissions. Türkiye applies a Tier 1 method, for this non-key category, quantifying emissions based on the plant-specific activity data and default emission factor, and using the following formula:

$$E_{CO2} = AD \cdot EF$$

Where:

E_{CO2} = emissions of carbon dioxide in tonnes

AD = quantity of soda ash produced (from trona) in tonnes

EF = emission factor per unit of soda ash produced

Collection of activity Data

The amount of soda ash produced is is directly taken from the plants. Data are acquired on a yearly basis and it is based on a questionnaire which is sent to the plants.

The production trend and emissions can be seen from the table below.

Table 4.16 Soda ash production and CO_2 emissions, 1990-2022

Year	Soda ash production by utilizing Trona (2009=100)	CO_2 Emissions (kt)
1990-2008	NO	NO
2009	100	24
2010	451	110
2011	538	132
2012	535	131
2013	511	125
2014	554	135
2015	549	134
2016	588	144
2017	850	208
2018	1905	466
2019	2278	557
2020	2170	531
2021	2514	615
2022	2671	653

Choice of emission Factor

The EF is confidential. The EF was held constant over the time series.

Uncertainties and Time-Series Consistency:

Türkiye assumes that the uncertainty of the EF is 1% and the uncertainty of the AD is ±5% in consistent with the 2006 IPCC Guidelines (2006 IPCC Guidelines, Volume 3 page 3.55).

Source-Specific QA/QC and Verification:

On the PRODCOM soda ash production data is available since 2009. PRODCOM data and plant specific data are compared and found consistent. Moreover, according to the 2006 IPCC Guidelines the emission from soda ash production can be calculated by either using the soda ash production data or using the trona consumption data. The emissions are calculated and reported using the soda ash production data. However, for quality control purpose the emissions is also calculated based on the trona consumption.

The plant mines the trona by solving it underwater and then pumps it into the process. The amount of solution pumped and its purity is known by the plant. Therefore, the amount of trona utilized is calculated and reported by the plant. When the two methods are compared 5% difference is found for 2022.

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculation:

No recalculations have been made to emissions from this category.

Planned Improvements

No further improvements are planned regarding this source.

4.3.8. Petrochemical and carbon black production (Category 2.B.8)

Source Category Description:

The petrochemical industry uses fossil fuels (e.g., natural gas) or petroleum refinery products (e.g., naphtha) as feedstocks. Within the petrochemical industry and carbon black industry, primary fossil fuels (natural gas, petroleum, coal) are used for non-fuel purposes in the production of petrochemicals and carbon black. The use of these primary fossil fuels may involve combustion of part of the hydrocarbon content for heat raising and the production of secondary fuels (e.g., off gases).

Türkiye reports CO_2 emissions from petrochemicals production. There is a single petrochemical producer in Türkiye and the company name is PETKIM. Carbon black was produced by PETKIM till 2001, however it was at a different production site and this production site was closed in 2001.

Styrene was produced between 2007-2012 in Türkiye by a single producer and Tier 1 approach used for the calculations of CH_4 emissions from styrene production according to 1996 IPCC Guidelines.

Sinificant fluctuations in production have occurred due to high volatility in demand. In 2016 and 2017, the plant exceeded its standard capacity by extending operational hours. In addition, once every four years, the plant decreases production and even ceases production for several months for maintenance. During these maintenance years, production levels drop dramatically.

During the production of petrochemicals various gases are generated. However PETKIM has a closed circuit that collects all the process gases, which includes greenhouses gases and combustible gases, and uses it as fuel. This fuel is named fuel gas and emissions due to the combustion of fuel gas is included in the energy sector. However, some of the fuel gas is combusted in the flare stacks and the emissions from the flare stacks are included in the IPPU category.

The figures below show the CO_2 emissions from flare stacks from the petrochemicals production at main production site of PETKIM between 1990 and 2022 and also carbon black production emissions at Kocaeli production site between 1990 and 2001.

Since PETKIM has a closed system for its stacks, all the methane emissions are assumed to be collected in the fuel gas. Hence it is covered in the energy sector.

Table 4.17 CO_2 emissions from petrochemical sector, 1990-2022

(kt)

Year	CO_2 emissions from carbon black production	CO_2 emissions from flaring	Total CO_2 emissions in petrochemical industry
1990	80.1	1.35	81.5
1995	104.7	1.35	106.1
2000	91.9	1.35	93.2
2005	NO	1.35	1.35
2010	NO	1.35	1.35
2011	NO	1.35	1.35
2012	NO	1.35	1.35
2013	NO	1.35	1.35
2014	NO	1.35	1.35
2015	NO	1.35	1.35
2016	NO	1.32	1.32
2017	NO	1.35	1.35
2018	NO	1.19	1.19
2019	NO	1.35	1.35
2020	NO	1.35	1.35
2021	NO	1.35	1.35
2022	NO	1.25	1.25

Methodological Issues:

CO_2 emissions are calculated by multiplying the amount of fuel gas burnt with the

$$E_{CO2} = M_{fuel\ gas}\ x\ Carbon\ content\ of\ fuel\ gas\ x\ 44/12$$

Where:

E_{CO2}= CO_2 emissions from production of petrochemical in tonnes
$M_{fuel\ gas}$ = Amount of fuel gas combusted as the flare gas in tonnes
44/12 = The molar weight ratio of carbondioxide to carbon

CO_2 emissions from carbon black production are calculated by Tier 1 methodology. The annual production amount is multiplied by the default CO_2 mission factor.

$$E_{CO2} = M_{carbon\ black}\ x\ Carbon\ Black\ CO_2\ EF$$

Carbon black production also causes CH_4 emissions. CH_4 emissions are calculated by Tier 1 methodology. The annual production amount is multiplied by the default CH_4 emission factor.

$$E_{CH4} = M_{carbon\ black}\ x\ Carbon\ Black\ CH_4\ EF$$

Collection of activity data

There is a single producer of petrochemicals in Türkiye. The amount of fuel gas combusted in the flare stacks is asked to the producer by an annual questionnaire. The amount of fuel gas combusted is confidential since there is one single company producing petrochemicals.

Choice of emission factor

The fuel gas composition is asked to the producer. The volumetric gas composition data is gathered and it is used to calculate the carbon content of fuel gas. Since there is one single company in Türkiye in the field of petrochemical production its fuel gas characteristic is confidential.

Uncertainties and Time-Series Consistency:

As 2006 IPCC Guidelines recommended default uncertainty values is used as ±10% for EF and AD based on expert judgement and table 3.27 in the 2006 IPCC Guidelines, Volume 3.

Source-Specific QA/QC and Verification:

A site visit was done to the PETKIM in 2017 by the TurkStat's inventory compilers. During this site visit all the process flow charts were examined and discussed with PETKIM engineers in order to understand emission pathways and ensure all emissions are included and not double counted.

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculation:

Including styrene production retrospectively resulted in a minor increase in CH_4 emissions, averaging 0.063 tonnes of CH_4 per year between the 2007 and 2012.

Planned Improvements

It is planned to calculate emissions using the MRV data.

4.3.9. Fluorochemical production (Category 2.B.9)

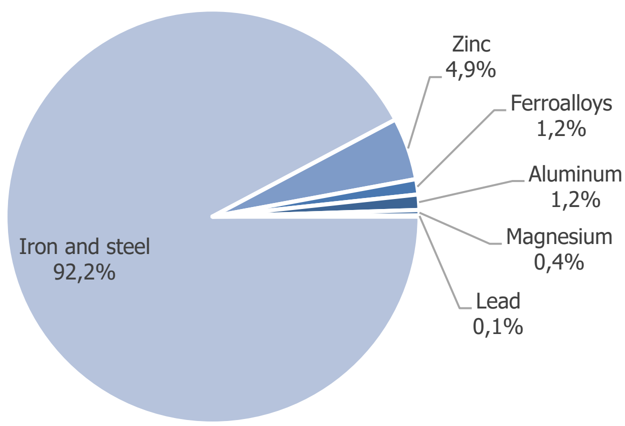
There is no fluorochemical production in Türkiye during the period 1990-2022.

4.4. Metal Industry (Category 2.C)

In 2022, the metal industry was responsible for 10 458 kt CO_2 eq., 15% of total emissions from the industrial processes and product use sector. The vast majority of emissions in the metal industry (92.2%) are from iron and steel production. Zinc industry was responsible for 508.5 kt CO_2 eq., 4.9% of metal emissions, aluminium production was responsible for 125.5 kt CO_2 eq., 1.2% of metal emissions and ferroalloys production was responsible for 124.9 kt CO_2 eq., 1.2 % of metal emissions. Magnesium production was responsible for 44 kt CO_2 eq. contributed 0.4% and lead production was responsible for 9.1 kt CO_2 eq. contributed 0.1% of sector emissions (see Figure 4.16).

Between 1990 (7 573 kt CO_2 eq.) and 2022 (10 458 kt CO_2 eq.), emissions from the metal industry increased by 38.1%, again driven in large part by the iron and steel industry, which increased by 39% during the time period, from 6 947.7 kt CO_2 eq. in 1990 to 9 645.8 kt CO_2 eq. in 2022. This increase in emissions was partially offset by the elimination of PFC emissions in aluminium production (PFC emissions were 424.7 kt CO_2 eq. in 1990 and it is 7.7 kt CO_2 eq. in 2022).

Figure 4.16 Emissions from metal industry, 2022



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

Source Category Description:

Iron and steel production processes result in CO_2 and CH_4 emissions to be covered under the IPPU category since carbon is used in the reduction process of iron oxides.

In Türkiye currently there are three integrated iron and steel production plants. These facilities include sinter production units, blast furnaces for pig iron production, and basic oxygen furnaces. Besides these plants, there are electric arc furnace mills operating in Türkiye. However, there is no direct reduced iron (DRI) production in Türkiye. Emissions from the combustion of carbon containing fuels (i.e. natural gas, fuel oil) for energy purposes are included in the energy chapter of this report.

The integrated steel production plants demand iron ore. These plants meet their need from both domestic and foreign markets. In Türkiye there is currently one plant producing pellet iron in order to supply the iron ore demand of the integrated steel plants.

Blast furnace units for pig iron production are the most emissive units among the iron and steel production processes. Iron oxide reduces into iron metal when reacted with carbon monoxide in the blast furnaces as shown in the reactions represented in equations below.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

$$3Fe_2O_3(s) + CO(g) \rightarrow 2Fe_3O_4(s) + CO_2(g)$$

$$Fe_3O_4(s) + CO(g) \rightarrow 3FeO(s) + CO_2(g)$$

Carbon monoxide is generated in the blast furnace from the carbon containing fuels (mainly coke) as can be seen in equation below. Coke provides the necessary carbon for both the reduction reactions as well the heat needed for melting the iron and the impurities. Besides, coke provides mechanical strength for the blast furnace burden.

$$2C(s) + O2(g) \rightarrow 2CO(g)$$

Limestone is used in the blast furnaces for removing acidic impurities from the ore. When limestone is heated up to about 1500 °C it releases carbon dioxide and left as CaO by the reaction shown in equation below. Then CaO reacts with the acidic impurities and deposits at the bottom of the blast furnace.

$$CaCO3(s) \rightarrow CaO(s) + CO2(g)$$

Sinter production is also an emissive process within the iron and steel industry. Sinter plants in Türkiye are within the integrated steel plants. Sintering is a heat treatment process that agglomerates iron ore fines and metallurgical wastes (i.e. collected dusts, sludge) into larger, stronger and porous particles necessary for blast furnaces charging. The sintering process involves the heating of iron ore fines by burning coke fines to produce a semi-molten mass that solidifies into porous pieces of sinter. Coke gas is usually used to ignite the sinter blend. This process also involves reduction of some iron oxides into iron metal within the iron ore fines. Therefore, the same reactions given above for the reduction of iron oxides also works for the sintering process and causes CO_2 release. During the sintering process high temperatures are achieved and limestone is calcined and release CO_2 emissions.

Basic Oxygen Furnaces (BOF) are also a part of the integrated steel plants. BOF processes the product of the blast furnace which is molten iron to produce steel. The BOF process also emits CO_2. The process involves oxygen blowing into the molten iron and stirring it. The oxygen reacts with impurities to purify molten iron and also reacts with dissolved carbon leaving as CO_2. This process converts iron into steel.

Electric Arc Furnaces (EAF) is another process unit for producing steel. Unlike BOF, only scrap iron and steel is used in the EAF to produce steel. The scrap metal is melted using high voltage electric arcs. There would be iron oxides in the feed of the EAF. Therefore, these iron oxides should be reduced to iron with the same reactions given above that cause CO_2 emissions. Metallurgical coke, petroleum coke, graphite, anthracite, carbon granules and natural gas may be used as the carbon source. Besides that, oxygen is blown into the molten steel in order to remove excess carbon and other impurities and to improve steel quality. This process step also releases CO_2 emissions due to reaction of oxygen and carbon.

Iron and steel production is classified as heavy industry and it requires vast amount of energy. All of the integrated steel plants in Türkiye recycle exhaust gases of the Blast Furnaces and Basic Oxygen Furnaces to meet up their energy requirement. These gases are collected and burnt in order to heat up the coke ovens, produce the high pressure steam requirement of the plant, pre heat the blast furnace air, produce electricity, heat up the rolls and for other small issues. Their emissions are covered in the energy sector of this report. Besides, integrated iron and steel production plants produce lime for their own consumption and lime production also causes CO_2 emission and it is covered in lime production part of IPPU.

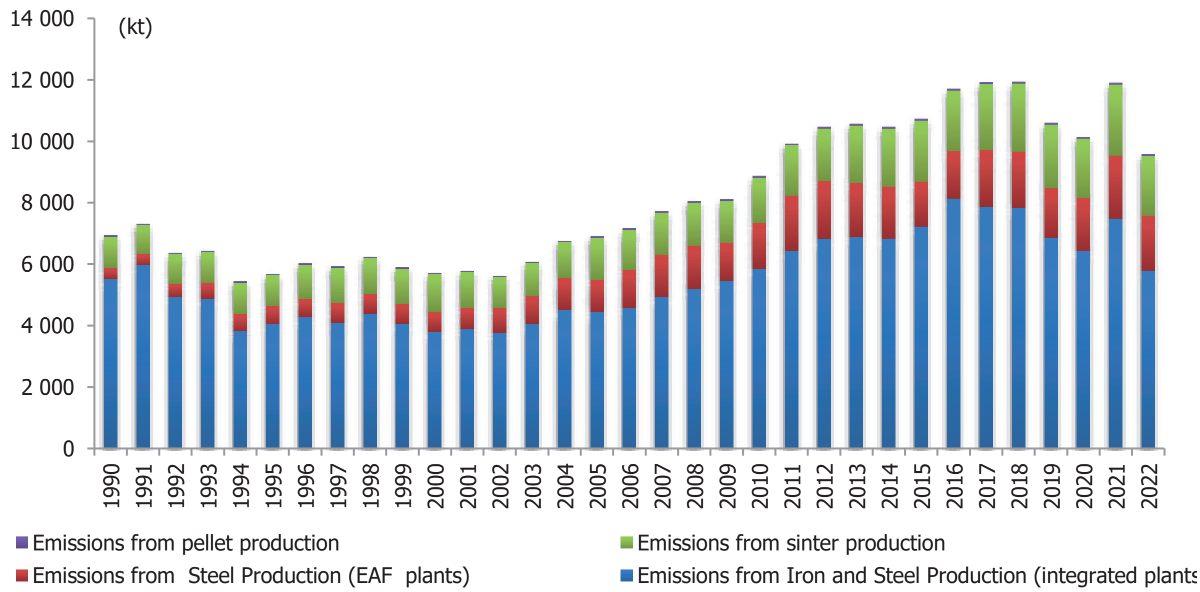
In Türkiye there are currently 3 integrated iron and steel plants and 26 electric arc furnaces mills operating. The table below presents 2.C.1 category CO_2 emissions between 1990 and 2022, and figure 4.17 shows the 2.C.1 category CO_2 emissions cumulatively revealing the emissions trend in the iron and steel production.

Table 4.18 CO_2 emissions allocations in 2.C.1 category, 1990-2022

(kt)

Year	Emissions from Iron and Steel Production (integrated plants)	Emissions from Steel Production (EAF plants)	Emissions from sinter production	Emissions from pellet production	Total emissions in 2.C.1 CRT category
1990	5 522	353	1 033	31	6 939
1995	4 048	605	988	26	5 668
2000	3 800	648	1 242	28	5 718
2005	4 449	1 057	1 358	34	6 898
2010	5 858	1 488	1 480	45	8 870
2011	6 433	1 800	1 642	45	9 920
2012	6 824	1 891	1 703	46	10 464
2013	6 892	1 760	1 867	44	10 564
2014	6 845	1 691	1 890	47	10 472
2015	7 235	1 458	1 985	46	10 725
2016	8 140	1 555	1 961	47	11 704
2017	7 871	1 849	2 150	45	11 914
2018	7 831	1 837	2 220	45	11 933
2019	6 857	1 629	2 067	46	10 599
2020	6 438	1 713	1 936	46	10 133
2021	7 486	2 058	2 306	47	11 898
2022	5 794	1 789	1 937	48	9 568

Figure 4.17 CO_2 emissions allocations within the 2.C.1 category, 1990-2022



CO_2 emissions from iron and steel production in 2022 was 9.6 million tons and it increased by 38% since 1990. Beginning by the year 2000 steel production have increased and Türkiye became the world's 8th biggest[6] crude steel producer reaching 35.3 million tons by 2022. In 2022 steel production decreased by 13%. Steel production capacity of Türkiye is over 50 million tons.

Methodological Issues:

For the calculation of CO_2 emissions from iron and steel production and sinter production in the integrated plants, the 2006 IPCC Tier 3 method is used.

The Tier 3 methodology equation for calculating CO_2 emissions from iron, steel and sinter production in the integrated plants is as follows:

$$E_{CO2} = \left[\sum_a (Q_a \times C_a) - \sum_b (Q_b \times C_b) \right] \times \frac{44}{12}$$

Where:

E_{CO2} = emissions of CO_2 to be reported in IPPU Sector, tonnes

a = input material a

b = output material b

Qa = quantity of input material a

Ca = carbon content of material a

Qb = quantity of output material b

Cb = carbon content of material b

44/12 = stoichiometric ratio of CO_2 to C

For the calculation of CO_2 emissions from pellet production, the 2006 IPCC Tier 1 method is used where total amount of pellet produced is multiplied with the emission factor.

$$E_{CO2,\ non\text{-}energy} = P \cdot EF_p$$

Where:

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

P = quantity of pellet produced nationally, tonnes

EF_p = emission factor, tonnes CO_2/tonne pellet produced

[6] https://worldsteel.org/media/press-releases/2023/december-2022-crude-steel-production-and-2022-global-totals/

CO_2 emissions from steel production in EAFs are calculated by applying the Tier 2 method which is the carbon balance calculation on an aggregated national level. The equation is given below:

$$E_{CO2} = \left[\sum_a (Q_a \times C_a) - \sum_b (Q_b \times C_b)\right] \times \frac{44}{12}$$

CH_4 emissions from sinter production are calculated using Tier 1 methodology. This is multiplication of the production data with the default emission factor as suggested in the 2006 IPCC Guidelines, the equations are shown below.

$$E_{CH4,\ non\text{-}energy} = SI \cdot EF_{SI}$$

Where:

$E_{CH4,\ non\text{-}energy}$ = emissions of CH_4 to be reported in IPPU Sector, kg

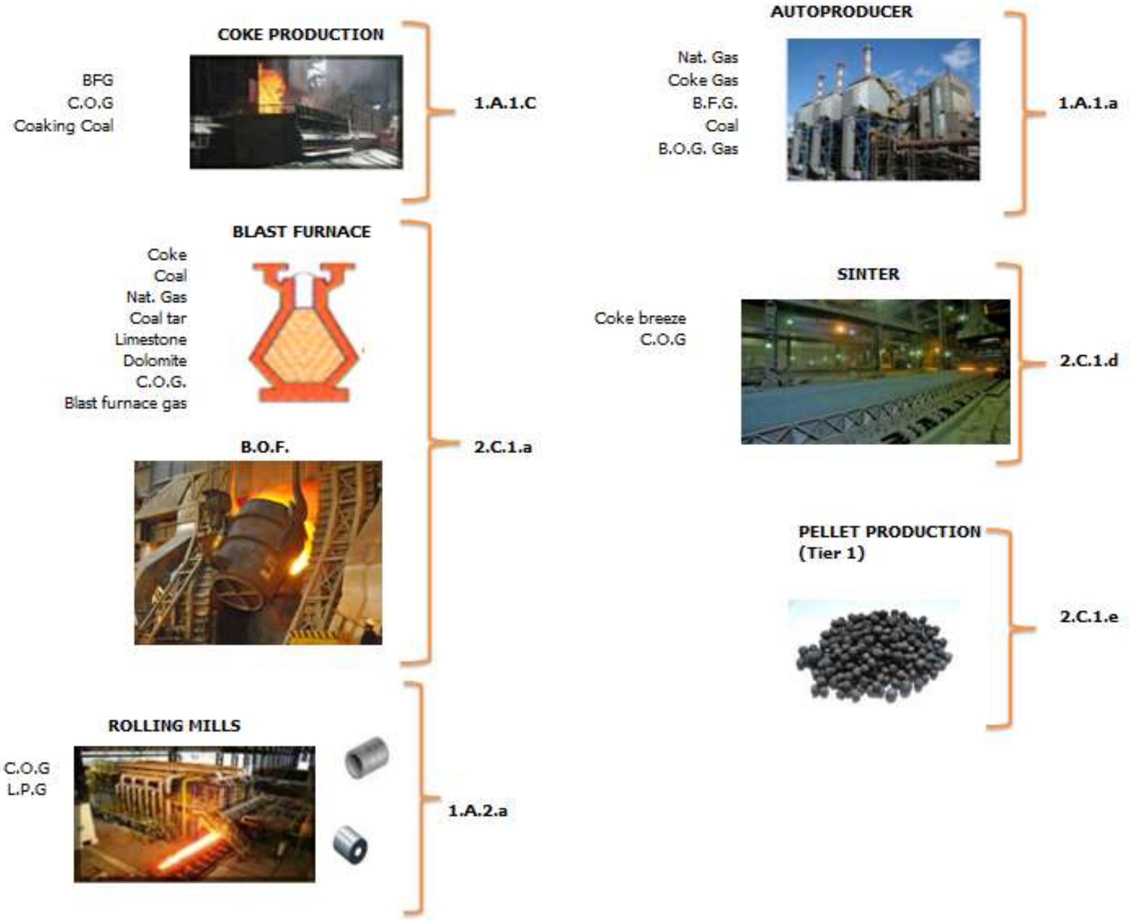
SI = quantity of sinter produced nationally, tonnes

EF_{SI} = emission factor, kg CH_4/tonne sinter produced

In Türkiye almost all of the by-product gases are collected and burnt for energy recovery. Therefore, it is assumed that no methane is emitted due to the pig iron production under 2C1 CRT category.

Figure 4.18 shows the allocations of the emissions from integrated iron and steel plants between Energy and IPPU sectors.

Figure 4.18 Allocations of the emissions from integrated iron and steel plants



Collection of activity data

To estimate CO_2 and CH_4 emissions at integrated facilities, Türkiye collects activity data via annual basis questionnaire from each of the three facilities. All the solid materials are weighted by scales whereas gaseous materials are measured by flowmeters and the annual values are calculated by a computer programmed totalizer.

Pellet is produced by a single company beside an iron mine in Türkiye. The activity data is obtained from this company.

The quantity data of crude steel production and raw material consumption at electric arc furnaces is obtained from Turkish Steel Producers Association by an annual basis questionnaire.

Each of the integrated facility keeps an energy balance table where all the fuel consumptions and generations are recorded annually. These tables are the main data source for the fuel consumptions. The consumption of non-fuel materials, (e.g. limestone, dolomite), are asked by a questionnaire.

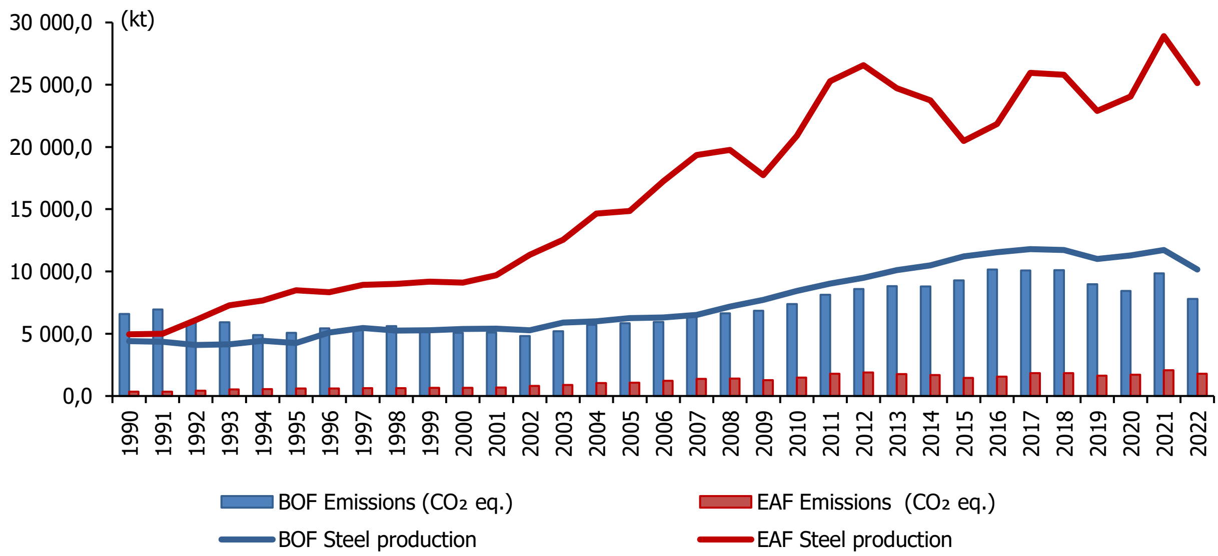
Sinter, pellet production and steel production by plant type are included in the table below.

Table 4.19 Sinter, pellet and iron & steel production by plant type, 1990-2022

(kt)

Year	Total pellet production	Total sinter production	Steel production (BOF)	Steel production (EAF)	Total steel production
1990	1 032	4 507	4 401	4 955	9 356
1995	855	4 285	4 259	8 501	12 760
2000	948	5 007	5 372	9 096	14 468
2005	1 120	5 355	6 254	14 847	21 101
2010	1 493	5 845	8 444	20 905	29 349
2011	1 495	6 361	9 023	25 275	34 298
2012	1 543	7 356	9 500	26 560	36 059
2013	1 480	7 617	10 111	24 723	34 834
2014	1 550	7 928	10 483	23 752	34 235
2015	1 547	8 567	11 215	20 482	31 697
2016	1 565	9 834	11 545	21 846	33 392
2017	1 501	9 342	11 795	25 963	37 758
2018	1 513	9 798	11 734	25 799	37 533
2019	1 547	9 101	11 002	22 884	33 887
2020	1 524	8 866	11 283	24 056	35 338
2021	1 568	9 553	11 721	28 902	40 622
2022	1 612	8 427	10 169	25 123	35 292

Figure 4.19 Comparing emissions (kt CO_2 eq.) and steel production (kt) from BOFs and EAFs



The CO_2 eq. emissions and total steel production (kt) of integrated plants (BOF) and Electric Arc Furnaces (EAF) are shown in the Figure 4.19. In 2022, the BOFs produced 28.8% and EAFs produced 71.2% of total iron and steel whereas the BOFs contributed 81.3% and EAFs contributed 18.7% of total emissions from iron and steel production.

Choice of emission factor

To estimate CO_2 emissions from integrated facilities, Türkiye collects any available plant-specific data on carbon content for integrated facilities and for the remaining materials the material-specific carbon content values from Table 4.3 of the 2006 IPCC Guidelines are applied for the entire time series. To determine carbon content, the facilities make laboratory analysis for the product iron and steel, for the process gases and for the coals used in the plant.

In order to estimate CO_2 emissions from EAFs, Türkiye collects raw material consumption and steel production data. These input and output data are aggregated on national level and multiplied by the default carbon contents for each raw material. However, the raw material consumption data is not available before the year 2013. Hence the average implied emission factor found to be 0.0712 t CO_2 /t steel produced between 2013 and 2016, and this factor is applied for the previous years.

To estimate CO_2 emissions from pellet production, the default emission factor (0.03 t CO_2/t pellet) from the 2006 IPCC Guidelines used for the entire time series.

To estimate CH_4 emissions from sinter production, the default emission factor (0.07 kg CH_4/t sinter) from the 2006 IPCC Guidelines applied.

Emission factors used in the calculations are provided in the table below.

Table 4.20 Emission factors iron and steel production

Activity	**CO_2 EF**
Pellet production (used in all-time series)	0.03 t/t pellet
EAF steel production	0.0712 t/t steel

Activity	**CH_4 EF**
Sinter production (used in all-time series)	0.07 kg/t sinter

Uncertainties and Time-Series Consistency:

Uncertainties for the activity data and the emission factors are estimated to be 10% and 8%, respectively. Because especially the activity data and the emission factors regarding the process gases (coke oven gas, blast furnace gas, oxygen steel furnace gas) are quite uncertain.

Source-Specific QA/QC and Verification:

There are three integrated iron and steel plants in Türkiye and plant specific data are gathered from these plants. These integrated steel plants were built as public economic enterprises and all of them have been privatized until 2006. Due to significant improvements on data recording after privatization, the integrated steel plants data are reliable after 2006. The integrated steel plants have similar steel production techniques therefore their data can be compared to each other. Coke consumed/steel produced, coke breeze consumed/sinter produced ratios are compared to each other in order to identify potential inconsistencies and reporting errors. Turkish inventory team had site visits and held meetings with experts from the field on integrated steel plants in 2016. Through the site visits and the meetings, process flow charts and data reporting issues were discussed in order to identify potential inconsistencies and reporting errors.

A comprehensive carbon mass balance analysis was conducted for each of the three integrated plants by accounting for all carbon-containing material inputs and outputs. The total emissions, including those from Industrial Processes and Product Use (IPPU) and Energy, were calculated and compared with the aggregated emissions for specific CRT categories associated with iron and steel production (categories 1.A.1.a, 1.A.1.c, 1.A.2.a, and 2.C.1). The results for 2022 are as follows:

- Emissions calculated via carbon mass balance for integrated plants: 19,761 kt
- Aggregated emissions for each CRT category for integrated plants: 18,561 kt
- Percentage of equivalence: 94%

The 94% equivalence percentage suggests that the calculated emissions are reliable, though there remains potential for enhancement.

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculations:

Changes in the carbon content of pig iron and natural gas from a single integrated plant resulted to a 0.05 kt increase in CO2 emissions in 2018 and 0.2 kt decrease in 2019.

Planned Improvements:

There is no further planned improvement in this sector.

4.4.2. Ferroalloys production (Category 2.C.2)

Source Category Description:

Ferroalloy is the term used to describe concentrated alloys of iron and one or more metals such as silicon, manganese, chromium, molybdenum, vanadium and tungsten. Silicon metal production is usually included in the ferroalloy group because silicon metal production process is quite similar to the ferrosilicon process. These alloys are used for deoxidising and altering the material properties of steel. Ferroalloy facilities manufacture concentrated compounds that are delivered to steel production plants to be incorporated in alloy steels. Silicon metal is used in aluminium alloys, for production of electronics. Ferroalloy production involves a metallurgical reduction process that results in significant CO_2 emissions.

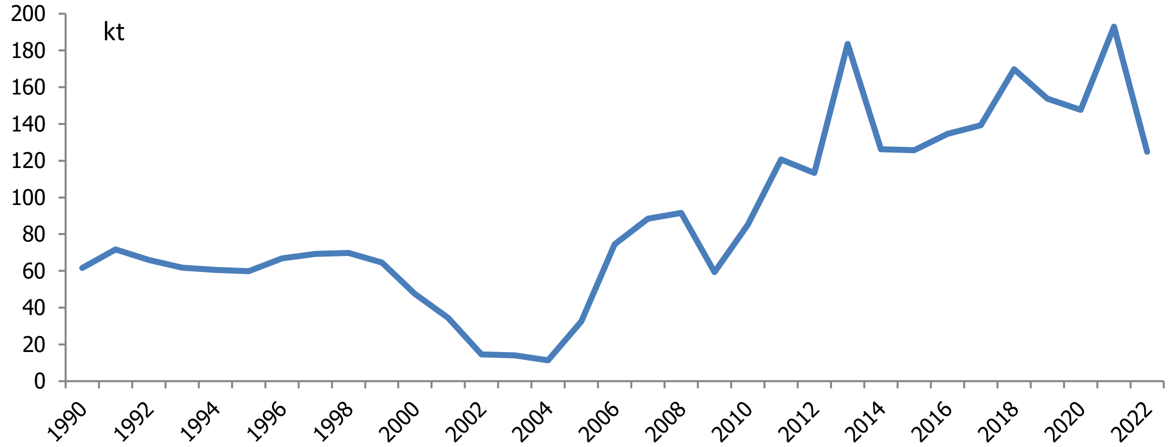
In Türkiye there are currently two ferrochrome producer. These two producer are using electric arc furnaces to melt scrap iron and chromite ore in the pot. Some metallurgical coke is added in the pot to reduce chromite and produce ferrochrome.

Between 2011 and 2014 some amount of ferrosilicon manganese was also produced. However, plants are closed due to the high production costs.

In this category; emissions from ferrochromium and ferrosilicon manganese production are considered. Other types of ferroalloys are not produced in Türkiye on industrial scale.

Although Türkiye is rich in terms of chrome mines, ferrochrome production is relatively low. This is due to high prices of energy in Türkiye. CO_2 emissions from ferroalloys production are driven by mainly ferrochrome production which is strongly depended on the energy prices. There was a decline in emissions between 2000 (47.6 kt CO_2) and 2004 (11.3 kt CO_2) owing to one of the ferrochromium producers was slowed down and finally out of operation during its privatization period. CO_2 emissions generally climbed until 2008 (91.6 kt CO_2) with economic growth before decreasing again in 2009 (59.3 kt CO_2) due to global economic recession and low demand on steel. There was then a steep increase between 2009 and 2013 (183.6 kt CO_2, an increase in emissions of 210%) due to two new investments on production of ferrosilica manganese. However ferrosilica manganese production plants were closed in 2012 and 2013 due to high energy costs. In 2022, CO_2 emissions from ferroalloy production was 124.9 kt.

Figure 4.20 CO_2 emissions from ferroalloys production, 1990-2022



Methodological Issues:

Türkiye reports CO_2 emissions from ferroalloys production following the IPCC Tier 1 approach, as shown in equation below. Ferroalloys production is not a key category.

CO_2 emissions from ferroalloys production

$$E_{CO2} = \sum_i (MP_i \cdot EF_i)$$

Where:

E_{CO2} = CO_2 emissions, tonnes
MP_i = production of ferroalloy type i, tonnes
EF_i = generic emission factor for ferroalloy type i, tonnes CO_2/ tonne specific ferroalloy product

Collection of activity data

Activity data are obtained from the two ferrochrome producers by a production survey on the yearly basis by TurkStat. Both the ferro-chromium production data and the reductant agent consumption data are gathered for all the time series. The coke used in the ferro chromium production is deducted from the total coke consumption of Türkiye in the energy sector to avoid a double counting.

Choice of emission factor

Türkiye applies the default CO_2 emission factors for ferro-chromium (1.3 t CO_2/t product) from the 2006 IPCC Guidelines.

Table 4.21 Ferroalloys production and emissions, 1990-2022

Years	Total ferroalloy production (1990=100)	CO_2 Emission (kt)
1990	100	62
1995	97	60
2000	77	48
2005	53	32
2010	138	85
2011	196	121
2012	184	113
2013	298	184
2014	205	126
2015	204	126
2016	219	135
2017	226	139
2018	276	170
2019	250	154
2020	240	148
2021	313	193
2022	203	125

Source-Specific QA/QC and Verification:

Ferroalloy production data was gathered directly from the plants. There are two ferro chrome producers in Türkiye. Both of them supply ferro alloy production and coke consumption data. The production and consumption ratios of the two producers are compared and found consistent. Furthermore, PRODCOM data for ferro alloy production compared every year and found consistent.

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Uncertainties and Time-Series Consistency:

Since the calculations are based on default Tier 1 EF and company derived production data, uncertainty values of EF are considered 25% and AD are 5% as recommended in Table 4.9 of 2006 IPCC Guidelines.

Recalculation:

There is no source specific recalculation for this submission.

Planned Improvements:

There are no planned improvements in this category.

4.4.3. Aluminium production (Category 2.C.3)

Source Category Description:

Türkiye estimates CO_2 and PFCs (CF_4 and C_2F_6) emissions from primary aluminium production. Primary aluminium is aluminium tapped from electrolytic cells or pots during the electrolytic reduction of metallurgical alumina (aluminium oxide). It thus excludes alloying additives and recycled aluminium.

Primary aluminium is molten or liquid metal tapped from the pots and that is weighed before transfer to a holding furnace or before further processing.

Eti Aluminium is Türkiye's only producer of primary aluminium and it is the country's only fully integrated producer which takes in untreated ore downstream and then has the capacity to fulfill every process requirement to the finished product. The company has its own bauxite ore mines located just 20 kilometers away from the factory and this is the starting point of its operations.

Eti Aluminium's Seydişehir Aluminium Plant, located in the Central Anatolia region of Türkiye, is an integrated primary aluminium production plant. From here the company is able to convert aluminium ore into metallic aluminium by first processing the ore and then shaping it through the use of casting, rolling and extrusion systems.

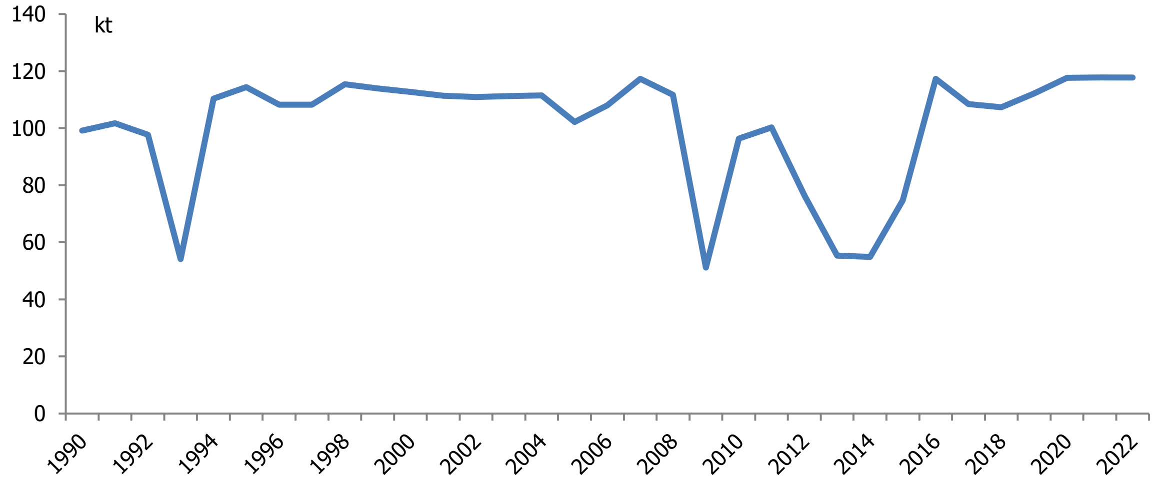
The integrated production process itself consists of five main production phases. These are bauxite mining, alumina production, liquid aluminium production, the alloying and casting of the liquid aluminium, and the last but by no means least, the production of semi and/or end products through the use of the aforementioned casting, rolling and extrusion processes.

Most carbon dioxide emissions result from the electrolysis reaction of the carbon anode with alumina (Al_2O_3). The consumption of prebaked carbon anodes and Søderberg paste is the principal source of process related carbon dioxide emissions from primary aluminium production. PFCs are formed during a phenomenon known as the 'anode effect' during liquid aluminium production via electrolysis. Eti Aluminium used Søderberg cells till the modernization of the aluminium production plant in 2015. In 2015 all of the Søderberg cells were replaced with the prebaked cells.

The CO_2 emissions from aluminium productions is shown in Figure 4.21. Overall between 1990 (99.2 kt) and 2022 (117.7 kt) emissions have increased by 18.7% due to increasing aluminium production of

Türkiye. In 1993 aluminium production decreased remarkably because of the excessive world aluminium stocks prior to the world economic recession of 1994. CO_2 emissions remained generally stable until a similar trend was seen in 2008 (111.8 kt), 2009 (51.2 kt) and 2010 (96.4 kt) similarly because of the world economic recession in 2008. In 2022, CO_2 emissions remained stable with respect to 2021.

Figure 4.21 CO_2 emissions from aluminium production, 1990-2022



CF_4 and C_2F_6 emissions are reported in the Table 4.22, fluctuations in the trend are due to Anode Effect parameter changes as well as primary aluminium production trend.

From the year 2006, PFCs emissions from the aluminium production plant are estimated using T3 methodology.

Eti Aluminium have communicated that after privatization in 2005, there has been great savings in energy consumption in 2006, at the same time there has been a decreasing trend in the number of anode effects. As it can be seen from the table below, reductions in PFCs emissions have occurred after 2006.

Methodological Issues:

CO_2 emissions from primary aluminium production are calculated by the T3 method for the entire time series. Eti Aluminium, the only primary aluminium producer in Türkiye, switched its production process in the mid of 2015. The company is now using Prebaked smelters. Before that Søderberg process was used to produce aluminium. For 1990-2014 CO_2 emissions come from only Søderberg cells. However, in 2015 Søderberg cells were switched to Prebaked cells. In 2016 CO_2 emissions come from only Prebaked cells.

CO_2 emissions from Søderberg cells

$$E_{CO2} = \left(PC \times MP - \frac{CSM \times MP}{1000} - \frac{BC}{100} \times PC \times MP \times \frac{S_p + Ash_p + H_p}{100} - \frac{100 - BC}{100} \times PC \times MP \times \frac{S_c + Ash_c}{100} - MP \times CD\right) \times \frac{44}{12}$$

Where:

E_{CO2} = CO_2 emissions from paste consumption, tonnes CO_2
MP = total metal production, tonnes Al
PC = paste consumption, tonnes/tonne Al
CSM = emissions of cyclohexane soluble matter, kg/tonne Al
BC = binder content in paste, wt %
S_p = sulphur content in pitch, wt %
Ash_p = ash content in pitch, wt %
H_p = hydrogen content in pitch, wt %
S_p = sulphur content in calcined coke, wt %
Ash_c = ash content in calcined coke, wt %
CD = carbon in skimmed dust from Søderberg cells, tonnes C/tonne Al
44/12 = CO_2 molecular mass: carbon atomic mass ratio, dimensionless

CO_2 emissions from Prebaked cells

$$E_{CO_2} = NAC \times MP \times \frac{C_a}{100} \times \frac{44}{12}$$

Where:

E_{CO2} = CO_2 emissions from paste consumption, tonnes CO_2

MP = total metal production, tonnes Al

NAC = net prebaked anode consumption per tonne of aluminium, tonnes C / tonne Al

C_a = carbon content in baked anodes, wt %

44/12 = CO_2 molecular mass: carbon atomic mass ratio, dimensionless

PFC emissions

PFCs are formed during a phenomenon known as the 'anode effect'. PFCs emissions have been estimated from the primary aluminium production multiplied for the relative (CF_4, C_2F_6), following a PFC emission by slope method (Tier 2 and Tier 3) IPCC methodology.

Due to the process change in Eti Aluminium, the company has switched to the Prebake cells just in 2015 after using Søderberg process for long years.

This technology change has leaded to changing the coefficient numbers and the difference between 2014-2015 has occurred because of this reason. Also PFC, C_2F_6 and CF_4 emission factors are recalculated in Eti Aluminium Facility in 2015-2016, calculation made by using the current coefficients in the Greenhouse Gas Monitoring Reporting Communiqué of MoEUCC and it can be seen from the table that there is a decrease trend between years 2016-2018. In the same years, total production value has also decreased. In the following table PFCs, CF_4 and C_2F_6 are reported.

Table 4.22 PFCs, CF_4 and C_2F_6 emissions 1990-2022

(kt CO_2 eq.)

Year	PFCs	CF_4	C_2F_6
1990	424 662	390 052	34 610
1995	367 648	337 684	29 964
2000	367 576	337 618	29 958
2005	358 611	329 384	29 227
2010	348 096	319 726	28 370
2011	325 717	299 171	26 546
2012	243 698	223 837	19 862
2013	179 607	164 969	14 638
2014	167 635	153 973	13 662
2015	82 057	75 369	6 688
2016	33 600	27 940	5 660
2017	22 629	18 817	3 812
2018	9 068	7 540	1 528
2019	15 373	12 783	2 590
2020	9 326	7 755	1 571
2021	6 096	5 069	1 027
2022	7 724	6 423	1 301

As shown in the table emission values of PFCs, CF_4 and C_2F_6 decreased after 2015, compared to previous years. Because Aluminium production system was changed from Søderberg to Prebaked smelted in 2015. PFCs are formed during a phenomenon known as the 'anode effect' during liquid aluminium production via electrolysis. There has been a decreasing trend in the number of anode effects after switching to prebaked smelter system.

Collection of activity data

To estimate CO_2 emissions, the parameters below are obtained from the single producer. The data are obtained from the producer company by an annual questionnaire. However, plant specific data can only be obtained for the years 2005-2015, and for 1990-2004 the default parameters are used as the emission factors and national statistics are used as the production data. The paste consumption data for 1990-2004 is assumed to be constant and same with the 2005 data. Total aluminium production is given in table 4.23 below.

Table 4.23 Aluminium production emissions, 1990-2022

Year	Aluminium Production (1990=100)	CO_2 emissions (kt)
1990	100	99.2
1995	115	114.4
2000	114	112.7
2005	109	102.2
2010	98	96.4
2011	103	100.3
2012	79	76.4
2013	59	55.3
2014	55	54.9
2015	83	74.7
2016	143	117.3
2017	137	108.4
2018	133	107.3
2019	142	112.1
2020	146	117.7
2021	145	117.8
2022	143	117.7

Choice of emission factor

Some of the CO_2 emission factors are provided by the facility while some are used as default values. In the tables below the emission factors used in the formula for Søderberg cells and Prebaked cells can be found.

Table 4.24 Emission factors for aluminium production with Søderberg cells, 2005-2015

Emission factor	Type of data	Value
PC (Paste consumption)	Plant specific	Confidential
CSM (Emissions of cyclohexane soluble matter)	Default	4 kg/tonne Al
BC (Binder content in paste)	Plant specific	Confidential
Sp (Sulphur content in pitch)	Plant specific	Confidential
Ashp (Ash content in pitch)	Plant specific	Confidential
Hp (Hydrogen content in pitch)	Default	3.3 wt %
Cc (Carbon content in calcined coke)	Plant specific	Confidential
Ashc (Ash content is calcined coke)	Plant specific	Confidential
CD (Carbon in skimmed dust from Søderberg cells)	Plant specific	Confidential

Note: For 1990-2004 PC value assumed to be constant and same with the 2005 data. All other parameters are default for the years 1990-2004

Table 4.25 Emission factors for aluminium production with Prebaked cells, 2015-2022

Emission factor	Type of data	Value
NAC (Net Prebaked Anode Consumption)	Plant specific	Confidential
Ca (Carbon content in baked anodes)	Plant specific	Confidential

Note that the company, Eti Aluminium, switched to the Prebake cells just in 2015 after using Søderberg process for long years. The system is not fully developed yet. NAC value is not measured but it is estimated by the process engineers of the company.

For the calculation of PFCs emissions, the company yearly supply data for the following parameters, from 1990:

- Primary aluminium production (tonnes);
- Anode effect (minute/day);
- CF_4 Slope coefficient;
- C_2F_6 Slope coefficient;
- CF_4EF (kg CF_4/tonnes aluminium);
- C_2F_6EF (kg C_2F_6/tonnes aluminium).

Uncertainties and Time-Series Consistency:

For CO_2 emissions, the uncertainty values of the T2 method is considered ±5% for the EF and ±1% for AD, as recommended in 2006 IPCC Guidelines Volume 3 (page 4.56). AD are relatively low as there is very little uncertainty in the data on annual production of aluminium and information is provided directly from the single producer. The CO_2 emission factor is also low as the mechanisms leading to emissions are well known. On the other hand, for F-gases, uncertainty values of T3 are considered 5% for EF and 2% for AD as recommended in 2006 IPCC Guidelines Volume 3 (page 4.56).

Source-Specific QA/QC and Verification:

Within the scope of the Turkish National Greenhouse Gas Emission Inventory Improvement Project, Türkiye's only primary aluminium producer, Eti Alüminyum A.Ş., was visited on July 2017 and detailed information on production processes and data recording systems were obtained. The emission calculation methodology, the parameters used in the formulation and the data gathered were discussed with sector experts. The methodology, the parameters and the data were also approved by the sector experts.

The production data is gathered from the producer and aggregated national implied emission factors are compared with IPCC default values. Due to the data confidentiality the IEFs cannot be tabulated in here.

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculation:

There is no source specific recalculation for this submission.

Planned Improvements:

No further improvements are planned.

4.4.4. Magnesium production (Category 2.C.4)

Magnesium is mainly used in electronics, defense, automotive and aircraft industries for its lightness and strength.

Türkiye estimates CO_2 and SF_6 emissions emissions from magnesium metal production for the first time in this submission. While metallic magnesium derived from mineral source, CO_2 released during calcination of carbanate-based ores.

Kar Mineral Madencilik is Türkiye's only producer of primary magnesium, launched its operation in 2016. Kar Mineral Madencilik uses Pigdeon method from dolomite mine for primary producing of magnesium metal.

The magnesium production consist of eight main production phases. These are dolomite mining, crushing, calcination, grinding, pelleting, reduction, rafination and casting.

Since all molten magnesium spontaneously burns in the presence of atmospheric oxygen, production and casting of all magnesium metal requires a protection system to prevent burning. The Magnesium production industry uses SF_6 as a cover gas to prevent the oxidation of molten magnesium.

Methodological Issues:

Türkiye implements Tier 1 method for calculation of CO_2 emissions from magnesium production. Primary production data collected from the plant as activity data and multiplied by the default IPCC EF.

$$\boldsymbol{E_{CO2} = (P_d \cdot EF_d).10^{-3}}$$

Where:

E_{CO2} = CO_2 emissions from primary magnesium production, Gg

P_d = national primary magnesium production from dolomite, tonnes
EF_d =Default emission factor for CO_2 emissions from primary magnesium production from dolomite, tonne CO_2 /tonne primary Mg produced

Tier 2 method for calculation of SF_6 is implemented which assumes that all SF_6 is consumed is subsequentlyemitted. Consuption of SF_6 data is gathered directly from the plant.

$$E_{SF6} = C_{SF6}$$

E_{SF6} = SF_6 emissions from magnesium casting, tonnes
C_{SF6} = consumption of SF_6 in magnesium smelters and foundries, tonnes

Consumed SF_6 which is also assumed to be equal to emissions reported by the plant. There was no use of other cover gases (HFC-134a or FK 5-1-12) hence emissions were not reported for these alternatives.

Collection of activity data

Primary magnesium production data is directly reported by the plant annually. Dolomite used as raw material for production of magnesium. The production trend can be seen from the table below. The production and emissions of single producer plant cannot be disclosed due to confidentiality reasons. Therefore, CO_2 emissions from magnesium production included in 2.A.1.a Steel production.

Table 4.26 Magnesium production, 2016-2022

Year	Magnesium Production (2016=100)
1990-2015	NO
2016	100.0
2017	720.2
2018	370.7
2019	779.8
2020	1153.4
2021	1099.4
2022	1747.1

SF_6 data is reported by the plant annually. Other cover gases (HFC-134a or FK 5-1-12) do not used by the plant. SF_6 emissions from magnesium casting processes and CO_2 eq. values can be seen from the table below.

Table 4.27 SF_6 emissions from magnesium casting, 2016-2022

Year	E_{SF6}	SF_6 Emissions (kt-CO_2 eq)
2016	0.040	0.94
2017	0.196	4.61
2018	0.260	6.11
2019	1.768	41.55
2020	2.444	57.43
2021	2.184	51.32
2022	1.872	43.99

Choice of emission factor

Türkiye applies default IPCC EF for primary magnesium producing which takes into account the type of raw material used. According to IPPC guideline Table 4.19 EF for dolomite is 5.13 tonnes CO_2 emission/tonne primary magnesium produced.

For magnesium casting processes Türkiye implement Tier 2 method that assumes all SF_6 consumed is emitted. Annual consumed SF_6 data gathered directly from the plant.

Uncertainties and Time-Series Consistency:

The 2006 IPCC Guidelines recommended uncertainty value of 5% is used for the AD since the magnesium production data are gathered directly from the single production plant. Uncertainty value of default EF is estimated 10% based on the expert judgement.

The uncertainty estimate is 5% according to IPCC guideline for the SF_6 consumption for magnesium casting data which gathered from purchase registers is reported directly by the plant.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

Recalculation:

There is no source specific recalculation for this submission.

Planned Improvements:

No further improvements are planned.

4.4.5. Lead production (Category 2.C.5)

Source Category Description

There are two primary processes for the production of rough lead bullion from lead concentrates. The first type is sintering/smelting, which consists of sequential sintering and smelting steps and constitutes roughly 78% of world-wide primary lead production. The second type is direct smelting, which eliminates the sintering step and constitutes the remaining 22% of primary lead production in the developed world. However, in Türkiye there is no primary lead production. Türkiye is producing lead by only smelting the recycled lead from vehicles' old batteries. There are over 25 million registered road motor vehicles and there is huge amount of vehicle batteries to be recycled every year in Türkiye. Therefore, there are many lead batteries recycling companies in Türkiye.

In lead recycling the batteries are crushed and then the scrap lead and plastic contents are separated by floating. Then the lead is put into a smelting furnace with some reductant agent (natural gas, fuel oil or metallurgical coke), silica, and iron. The furnace is heated up and the lead is melted in the furnace. During this process oxides are carbonated and leave the furnace as CO_2.

Methodological Issues:

Lead production is not a key category in Türkiye, and due to lack of data, the Tier 1 is applied to calculate CO_2 emissions by multiplying process specified to lead production data, as shown in equation below.

$$E_{CO2} = S \cdot EF_s$$

Where:

E_{CO2} = CO_2 emissions from lead production, tonnes

S= quantity of lead produced from secondary materials, tonnes

EF_S = emission factor for secondary materials, tonne CO_2 / tonne lead produced

The lead production data is known for only 1990-1996. Besides that, the amount of vehicle batteries recycled is known for the years 2007 and 2022. There is no data between 1997 and 2006. The specialists from the production field indicated that lead production amount is 60% of the vehicle batteries recycled by weight and this assumption is used for the estimation of secondary lead production. The amount of lead produced between 1997 and 2006 is estimated by interpolation.

Collection of activity data

There are many companies in Türkiye recycling vehicle batteries for lead recovery. Since old batteries are classified as dangerous waste, it is statistically overseen. The amount of vehicle batteries recycled is known for the years 2007-2022. The data is gathered from TurkStat data bases and Ministry of Environment, Urbanization and Climate Change. It is assumed that 60% of the waste battery weight is recycled as lead. This assumption is based on the experts who work in the lead smelting industry. 1990-1996 lead production data is found in the 8th five years development plan of Türkiye. The data for the years 1997-2006 are estimated by interpolation. In the table below the amount of vehicle batteries recycled and consequently the amount of lead produced in the smelting process is shown. The emissions from lead production is also shown in the same table.

Table 4.28 Lead production and CO_2 emissions from lead production, 1990-2022

Year	Recycled waste batteries (kt)	Lead production from waste batteries (kt)	CO_2 emissions (kt)
1990	No Data	11.0	2.2
1995	No Data	11.1	2.2
2000	No Data	18.5	3.7
2005	No Data	24.8	5.0
2010	55.0	33.0	6.6
2011	59.4	35.6	7.1
2012	59.5	35.7	7.1
2013	69.0	41.4	8.3
2014	61.3	36.8	7.4
2015	71.4	42.9	8.6
2016	66.4	39.8	8.0
2017	73.9	44.3	8.9
2018	72.6	43.5	8.7
2019	73.5	44.1	8.8
2020	78.5	47.1	9.4
2021	77.1	46.3	9.3
2022	75.6	45.4	9.1

Choice of emission factor

Emission factor of 0.20 tonne of CO_2 / tonne of lead produced is used in the calculations. This is the process type specific emission factor for the treatment of secondary raw materials in the 2006 IPCC Guidelines, Table 4.21.

Uncertainties and Time-Series Consistency:

National production data for the amount of vehicle batteries are used as the activity data and it is estimated that 60% by weight of the amount of batteries recycled is recovered as lead. Due to this assumption the activity data has an uncertainty of 25% relying on the expert judgement. The process type emission factor has an uncertainty of 20% by default.

Source-Specific QA/QC and Verification:

The weight data of recycled batteries is gathered from Ministry of Environment, Urbanization and Climate Change (MoEUCC). The same data is also produced by TurkStat. When this two data sets from different sources are compared they are found consistent.

In order to estimate the amount of lead produced using the amount of batteries recycled data, the biggest two lead smelter company were asked and the production engineers and environmental responsibles gave necessary information. One company responsible declared 55-60% of lead recovery, the other company declared 65% of lead recovery from the old vehicle batteries by weight. Therefore, these information is consistent with the assumption that 60% of lead is recovered by weight.

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculation:

The amount of lead production from waste batteries in 2021 has been recalculated by linear interpolation due to the availability of 2022 survey data, resulting in a 0.8 kt decrease in CO_2 emissions for 2021.

Planned Improvements:

No further improvements are planned at this time.

4.4.6. Zinc production (Category 2.C.6)

Source Category Description:

Zinc production in Türkiye consist of secondary processes, currently there is no primary zinc production. There was a single primary production plant (CINKUR), located in Kayseri, produced primary zinc between the years 1968 and 1999. The plant was producing zinc by utilizing zincoxide ore by pyrometallurgical (Imperial Smelting Furnace) process until it closed in 1999.

Zinc consumed in variety of areas including galvanizing where zinc coating is applied to steel in order to prevent corrosion, zinc alloys production, agricultural fertilizers, chemicals and paint industries.

Türkiye estimates CO_2 emissions from secondary zinc production first time in this submission. Secondary zinc production began in 1999 with single plant which stopped its operations for the years 2003, 2004 and 2009. Second plant launced operation in 2010 and three of them started their operations in 2015.

For secondary zinc production, electric arc furnace (EAF) dust, which captured during the recycling of galvanized steel, is main raw material. Flotation residuals from zinc mines are also used in production of secondary zinc.

In the Waelz kiln process, EAF dust and mine residuals enters a kiln along with a reducing agent (metallurgical coke or anthracite) and limestone at a temperature of 1200-1300 C. As the feed material moves down the kiln, zinc transformed to gas and turned to Waelz oxide which is captured, cooled and leached in order to produce zinc concentrate. The use of carbon-containing reducing agent in high-temperature fuming process results in non-energy CO_2 emissions. Emissions from fuels consumed for energy purposes during the production of zinc are accounted for in the Energy chapter.

Methodological Issues:

Estimations are based on the Tier 1 method described in the 2006 IPCC Guidelines. In order to calculate CO_2 emissions from primary zinc production, the default EF is multiplied with zinc production data as shown in the equation below.

$$E_{CO2} = Zn \cdot EF_{default}$$

Where:

E_{CO2} = CO_2 emissions from primary zinc production, tonnes

Zn = quantity of zinc produced, tonnes

$EF\ default$ = Default emission factor, tonnes CO_2/ tonne zinc produced

CO_2 emissions from secondary zinc production calculated as shown in the equation below.

$$E_{CO2} = WK \cdot EF_{WK}$$

E_{CO2} = CO_2 emissions from secondary zinc production, tonnes

WK = quantity of zinc produced by Waelz kiln process, tonnes

$EF\ default$ = emission factor for Waelz kiln process, tonnes CO_2/ tonne zinc produced

Collection of activity data

To estimate CO_2 emissions from secondary zinc production, production data obtained from the plants by a questionnaire in which retrospective data also demanded.

For primary zinc production the plant stopped its activities in 1999. And it changed its owners many times from then. The newest owners of the plant have no information dating back to those years. Fortunately, the capacity utilization rate and the total zinc production capacity of the plant is found in the records of the ministry of state responsible for privatization (2001). By multiplying the production capacity of the plant with the capacity utilization rate, the production data of the plant are estimated for 1990-1999.

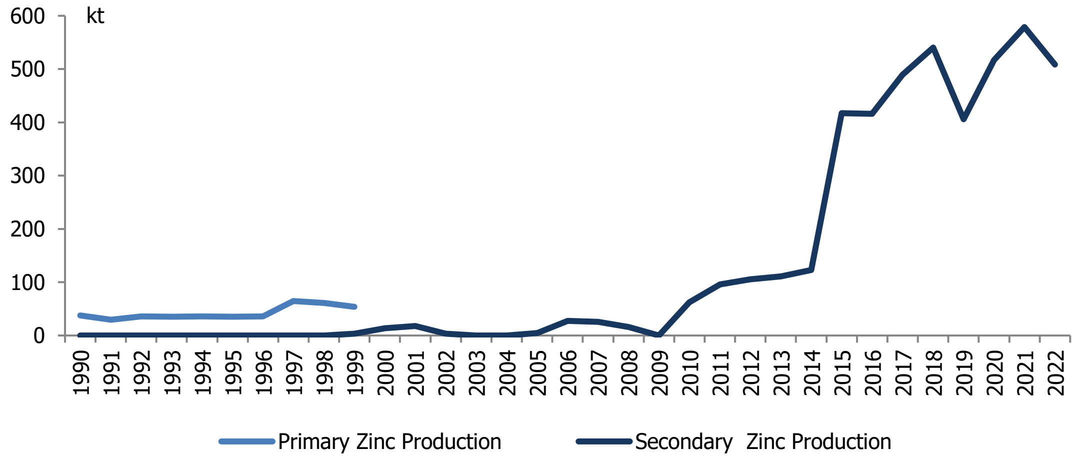
The table below shows the amount of primary and secondary zinc production and CO_2 emissions.

Table 4.29 Zinc productions and CO_2 emission (kt), 1990-2022

Years	Primary Zinc Production	Emissions from Primary Zinc Production CO_2	Secondary Zinc Production	Emissions from Secondary Zinc Production CO_2	Total Emissions from Zinc Production CO_2
1990	22.0	37.8	NO	NO	37.8
1995	20.4	35.1	NO	NO	35.1
2000	NO	NO	3.7	13.7	13.7
2005	NO	NO	1.3	4.6	4.6
2010	NO	NO	17.0	62.2	62.2
2011	NO	NO	26.2	95.8	95.8
2012	NO	NO	28.9	105.6	105.6
2013	NO	NO	30.3	110.7	110.7
2014	NO	NO	33.7	123.2	123.2
2015	NO	NO	113.9	417.0	417.0
2016	NO	NO	113.7	416.2	416.2
2017	NO	NO	133.7	489.3	489.3
2018	NO	NO	147.6	540.3	540.3
2019	NO	NO	110.9	406.0	406.0
2020	NO	NO	141.2	516.9	516.9
2021	NO	NO	158.2	578.9	578.9
2022	NO	NO	138.9	508.5	508.5

NO = Not Occurred

Figure 4.22 CO_2 emissions from primary and secondary zinc production, 1990-2022



Choice of emission factor

Default emission factor of 1.72 tonne of CO_2/tonne of zinc produced is used in the primary zinc production calculations. This is the default emission factor in the 2006 IPCC Guidelines, Table 4.24 based on weighting of 60% Imperial Smelting and 40% Waelz Kiln. For the calculation of emissions from secondary zinc production, Waelz kiln process emission factor of 3.66 tonne of CO_2/tonne of zinc produced is used.

Uncertainties and Time-Series Consistency:

Uncertainty value for EF is considered 50% as recommended in the 2006 IPCC Guidelines Volume 3 Table 4.25 due to the use of default EF. Since production data gathered directly from the plants, the uncertainty value for AD is considered 5%.

Source-Specific QA/QC and Verification:

Experts from zinc trader and waelz oxide producer companies in Türkiye are personally communicated and by this way it is verified that Türkiye's only primary zinc producer was CINKUR and it was closed in 1999. CINKUR's zinc production data is also found in the 8th five years development plan of Türkiye (2001) and it is stated that CINKUR is roughly producing 20.000 tons zinc/year which is in line with our calculated production data for the years between 1990 and 1996.

CO_2 emissions from secondary zinc production is estimated first time in this submission. Secondary zinc production data which are collected from the plants via questionnaire for this inventory calculations, are compared with PRODCOM and found consistent.

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

Recalculation:

There is no source specific recalculation for this submission.

Planned Improvements:

The activities of secondary zinc producers will continue to be examined in next submissions.

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

4.5.1. Lubricant use (Category 2.D.1)

Source Category Description:

Lubricants are mostly used in industrial and transportation applications. Lubricants are produced either at refineries through separation from crude oil or at petrochemical facilities. They can be subdivided into (a) motor oils and industrial oils, and (b) greases, which differ in terms of physical characteristics (e.g., viscosity), commercial applications, and environmental fate.

The use of lubricants in engines is primarily for their lubricating properties and associated emissions are therefore considered as non-combustion emissions and reported in the IPPU Sector.

Methodological Issues:

Detailed activity data on lubricants are not available in Türkiye and CO_2 emissions calculation is based on the amount of lubricant consumption is obtained from IEA - Eurostat - UNECE Energy Questionnaire - Oil table of Türkiye. Total consumption data for all lubricants (i.e. no separate data for oil and grease) is calculated by subtracting exports-imports and stock changes from production data. T1 method which is formulated by Equation 5.2 in 2006 IPCC Guidelines is used to calculate CO_2 emission. Lubricant consumption data and the weighted average oxidation during use (ODU) factor and default carbon content factor for lubricants as a whole is used as default value for the calculation. The amount of lubricant consumed in terms of kt converted to in terms of TJ by multiplying it with a factor (40.2). The following table shows the amount of lubricant used and the CO_2 emissions, from 1990 to 2022.

As activity data is calculated by subtracting exports-imports and stock changes from production data, fluctuations between some of the years are through the changes of these indicators. Due to decreasing import of lubricant in 2015 from 421 ktons to 199 ktons in 2016, resulted 47% decrease in activity data.

Table 4.30 The Amount of lubricant used and CO_2 emissions, 1990-2022

(kt)

Year	Lubricant use	CO_2
1990	297	175.1
1995	339	199.9
2000	460	271.2
2005	667	393.3
2010	713	420.4
2011	1 416	834.9
2012	998	588.4
2013	894	527.1
2014	654	385.6
2015	432	254.7
2016	229	135.0
2017	243	143.3
2018	328	193.4
2019	211	124.4
2020	203	119.5
2021	277	163.1
2022	236	139.0

Uncertainties and Time-Series Consistency:

Because the default ODU factors developed are very uncertain, as they are based on limited knowledge of typical lubricant oxidation rates, the default uncertainty for EF is 50%. For AD uncertainty value is considered to be 25%.

Source-Specific QA/QC and Verification:

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculation:

There is no source specific recalculation for this submission.

Planned Improvements:

No further improvements are planned at this time.

4.5.2. Paraffin wax use (Category 2.D.2)

Source Category Description:

The category, as defined here, includes such products as petroleum jelly, paraffin waxes and other waxes, including ozokerite (mixtures of saturated hydrocarbons, solid at ambient temperature). Paraffin waxes are separated from crude oil during the production of light (distillate) lubricating oils. Paraffin waxes are categorized by oil content and the amount of refinement.

Waxes are used in a number of different applications. Paraffin waxes are used in applications such as: candles, corrugated boxes, paper coating, board sizing, food production, wax polishes, surfactants (as used in detergents) and many others. Emissions from the use of waxes derive primarily when the waxes or derivatives of paraffin are combusted during use (e.g., candles), and when they are incinerated with or without heat recovery or in wastewater treatment (for surfactants).

Methodological Issues:

Detailed activity data on paraffin wax use are not available in Türkiye and CO_2 emissions calculation is based on the amount of paraffin waxes consumed in a country which is obtained from IEA - Eurostat - UNECE Energy Questionnaire - Oil table of Türkiye. Total consumption data for paraffin waxes is calculated by subtracting exports-imports and stock changes from production data. Tier 1 method formulated as Equation 5.4 in 2006 IPCC Guidelines is used with default carbon content and ODU factor. The following table shows the amount of paraffin wax used and resulting CO_2 emissions, 1990 to 2022.

Table 4.31 The Amount of paraffin wax used and CO_2 emissions, 1990-2022

(kt)

Year	Paraffin wax use	CO_2
1990	14	8.3
1995	5	2.9
2000	10	5.9
2005	89	52.5
2010	19	11.2
2011	32	18.9
2012	29	17.1
2013	11	6.5
2014	23	13.6
2015	20	11.8
2016	19	11.2
2017	14	8.3
2018	22	13.0
2019	23	13.6
2020	25	14.6
2021	11	6.7
2022	15	8.9

As activity data is calculated by subtracting exports-imports and stock changes from production data, fluctuations between some of the years are through the changes of these indicators. Due to increasing import of paraffin wax in 2014 resulted 109% increase in activity data.

Uncertainties and Time-Series Consistency:

Uncertainty values of AD is considered to be 25%, on the other hand since the ODU factor is highly dependent on specific country conditions and policies, the default EF exhibits an uncertainty of 100% according to the 2006 IPCC Guidelines.

Source-Specific QA/QC and Verification:

In this submission for minimizing calculation errors, emission calculation was done by using two different software and results were compared.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Recalculation:

There is no source specific recalculation for this submission.

Planned Improvements:

No further improvements are planned.

4.6. Electronics Industry (Category 2.E)

A research for this category, has been done by taking into consideration of relevant sectors and gases. According to the results, it has been appeared that F-gases have not been used in the manufacturing processes of these sectors. However, it is founded that some gases have been used with the aim of research and development.

Source category description

The sub-sector only consists of the following sub-application: 2.E.5 Other, other electronic uses.

Methodological issues

This section presents the results of research conducted by the Ministry of Environment, Urbanization, and Climate Change. As stated above, the results indicate that F-gases are not used in the manufacturing of flat panel displays, photovoltaic products, and semiconductors. This information was obtained by contacting the largest companies within the relevant sectors.

However, it has been observed that CF_4, CHF_3, and SF_6 are used for research and development in the semiconductor products sector. Therefore, these gases are categorized under 2.E.5 as 'other electronic uses.'

According to the research, the use of these gases began in 2010. For emission reporting purposes, it is assumed that the same amount of gas was used each year. This assumption is based on expert judgment. The Ministry of Environment, Urbanization, and Climate Change (MoEUCC) conducted a survey with Turkey's leading company with an R&D department in the electronic industry, and the numbers were assessed based on the survey results.

Table 4.32 shows the consumption amount of each gases which are consumed for the research and development purpose.

Table 4.32 Consumption of each gases, 2010-2022

(kg)

Years	CF_4	HFC-23	SF_6
2010	1.2	6	1 848
2011	1.2	6	1 848
2012	1.2	6	1 848
2013	1.2	6	1 848
2014	1.2	6	1 848
2015	1.2	6	1 848
2016	1.2	6	1 848
2017	1.28	6.4	1 984.7
2018	1.31	6.56	2 501.7
2019	1.32	6.61	2 524.2
2020	1.34	6.72	2 569.6
2021	1.49	7.46	2 852.3
2022	1.57	7.88	3 012

Türkiye's economy grew 5.6 percent in 2022 and the value of consumption of each gas has determined for 2022 by using the value of economic grew.

In section I.19 of the ERT assessment report, as stated in the report on the individual review of the inventory submission of Türkiye submitted in 2023, the ERT noted that the Party did not correct the assumed increase in emissions between 2017 and 2018. Since Turkey's economy grew by 2.6 percent in 2018, the consumption value of each gas was determined.

Recalculation:

There is no recalculation for this submission.

Planned Improvements:

No further improvements are planned.

4.7. Product Use as Substitutes for ODS (Category 2.F)

Source Category Description:

Production of fluorochemicals does not exist in Türkiye. Therefore, all demand for these gases is met by imports.

The sub sector emissions of fluorinated substitutes for ODS consist of the following sub application;

- 2F3 emissions from fire protection
- 2F6 emissions from other applications

Methodological Issues:

The methodology used to estimate HFCs emissions from the sub-sector has been based on the 2006 IPCC Guidelines, using the model provided by the IPCC, which calculate emissions following T1 method. Inventory calculations have been based on the raw trade data (import and export) provided for each gas by Ministry of Trade.

It should be noted that HFCs are being used as alternatives to CFCs since 1999. Since then it is thought that HFCs are used in different industrial sectors. However due to lack of information, it is assumed that most of HFCs gases, excluding HFC-227ea that is used only in fire extinguishers, are used in refrigeration and air conditioning sector. Due to this reason, these gases are calculated according to the calculation assumptions for refrigeration and air conditioning but calculation results are reported under "Other Applications" title in 2F category. As it is written in 2006 IPCC Guidelines, following assumptions are used in a hybrid Tier 1a/b approach for calculations;

- Servicing of equipment containing the refrigerant does not commence until 3 years after the equipment is installed.
- Emissions from banked refrigerants average 3% annually across the whole refrigeration and air conditioning application area.
- In a market, two thirds of the sales of a refrigerant are used for servicing and one third is used to charge new equipment.
- The average equipment lifetime is 15 years.
- The complete transition to a new refrigerant technology will take place over a 10 years period.

For calculation of HFC-227ea, expert judgements are considered. According to the information which is obtained from discussion with experts who are working under the Protection of Ozon Layer Division of MoEUCC and Turkish Fire Protection and Training Foundation (TUYAK) which is representative of fire sector, HFC-227ea is mostly consumed in fire protection application in Türkiye. Regarding to this information, this gas is reported under "2F3 Fire Protection" category. As it is stated in the 2006 IPCC Guideline, HFCs in this application area, are emitted over a period longer than one year. To consider this, spreadsheet which is proposed by guideline is used for calculation.

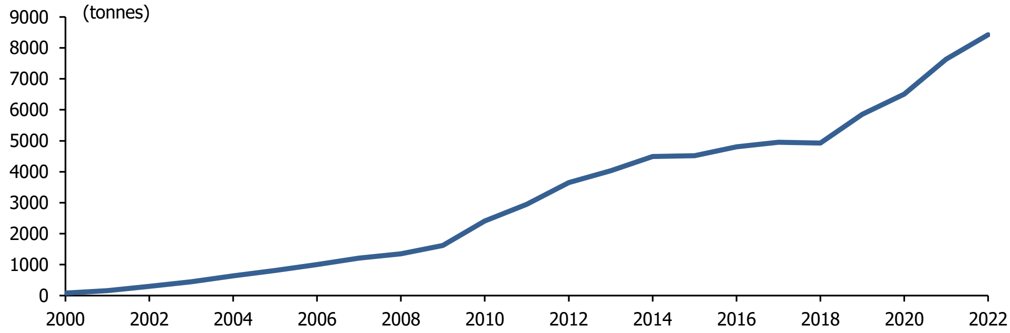
Uncertainties and Time-Series Consistency:

Table 4.33 and Figure 4.23 present total HFCs emissions from 1999 to 2022. Increasing trend in emissions is clearly observed from these presentations. The reason behind this can be explained by the prohibition of CFCs in the country. Since 1999, HFCs have been used as substitution of CFCs (Values of 1999 has been calculated due to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories).

Table 4.33 Total HFCs emissions, 1999-2022

Year	HFCs Emissions (tonnes)	HFCs Emissions (kt CO_2 eq.)
2000	81.3	105.2
2005	808.6	1043.9
2010	2412.4	2789.3
2011	2949.9	3142.0
2012	3654.4	3891.9
2013	4030.0	4095.3
2014	4490.5	4519.2
2015	4522.5	4424.8
2016	4806.7	4694.1
2017	4955.5	4831.7
2018	4929.9	4646.7
2019	5858.0	5249.0
2020	6508.4	6008.3
2021	7635.8	6716.1
2022	8425.8	10184.1

Figure 4.23 Total HFCs emissions, 1999-2022



Above presentation shows aggregated emissions caused by HFCs including HFC-23, HFC-32, HFC-41, HFC-43-10mee, HFC-125, HFC-134, HFC-134a, HFC-143, HFC-143a, HFC-152a, HFC-227ea, HFC-236fa, HFC-245ca, and HFC-365 mcf. Moreover, table below separately indicates emissions from these gases for specific years. All emission values are presented in tonnes and for each gas emissions are calculated related to Tier 1a/1b method of IPCC. Inventory calculations have been based on the raw trade data (import and export) provided for each gas by Ministry of Trade and the change in graph is consistent with number of import and export.

Table 4.34 HFCs Emissions

(tonnes)

Substance	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
HFC-23	0.02	0.29	0.57	0.63	5.40	4.70	4.10	3.66	5.33	4.70	3.58	3.18	2.97	2.52	14,35
HFC-32	NO	NO	NO	NO	0.01	0.01	0.5	0.6	0.7	3.5	86.9	179.3	323.7	600.1	1,066
HFC-41	NO	NO	0.03	0.02	0.03	0.03	0.02	0.02	0.02	0.01	0.08	NO	NO	NO	NO
HFC-43-10mee	NO	NO	NO	0.04	0.08	0.07	0.15	0.12	0.51	0.88	1.65	3.20	2.97	2.84	2.63
HFC-125	NO	NO	0.7	1.2	3.6	6.7	15.3	25.5	21.7	27	30.5	35.7	27.9	102.2	567.2
HFC-134	NO	NO	NO	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
HFC-134a	80.4	791.4	2,066.3	2,285.4	2,770.4	2,877.5	3,143.3	3,000.0	3,153.4	3,215.9	2,978.3	3,303.5	3,778.3	3,775.9	4,243
HFC-143	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NO	NO	NO
HFC-143a	NO	NO	NO	NO	0.00	0.00	0.00	2.83	2.41	2.05	1.74	1.48	1.26	30.57	233.1
HFC-152a	0.78	14	331.4	642.2	849.4	1,109.1	1,274.5	1,418.2	1,537.6	1,605.6	1,720.6	2,217.5	2,233.4	2,969.1	2,136.3
HFC-236fa	NO	NO	0.68	1.66	3.07	4.12	4.11	4.09	6.03	6.77	9.45	9.58	11.80	13.83	15.78
HFC-245ca	NO	NO	0.02	1.14	0.97	0.82	2.65	2.26	1.92	1.63	1.42	1.24	0.99	5.58	0.00
HFC-245fa	NO	NO	NO	NO	NO	NO	12	25.20	29.05	30.51	28.16	23.93	32.85	29.79	27.64
HFC-365mfc	NO	NO	0.12	1.10	1.08	0.92	0.78	0.66	0.56	0.48	0.41	1.04	0.19	1.08	0.00
HFC-227ea	0.13	2.87	12.67	16.55	20.45	26.06	33.23	39.33	47.58	56.61	67.10	78.33	92.14	102.31	119.93

The calculation method is IPCC T1 for all substances given above.

HFC emissions have increased significantly compared to previous years, largely due to gas importers stockpiling HFCs ahead of the licensing process that started in May 2023.

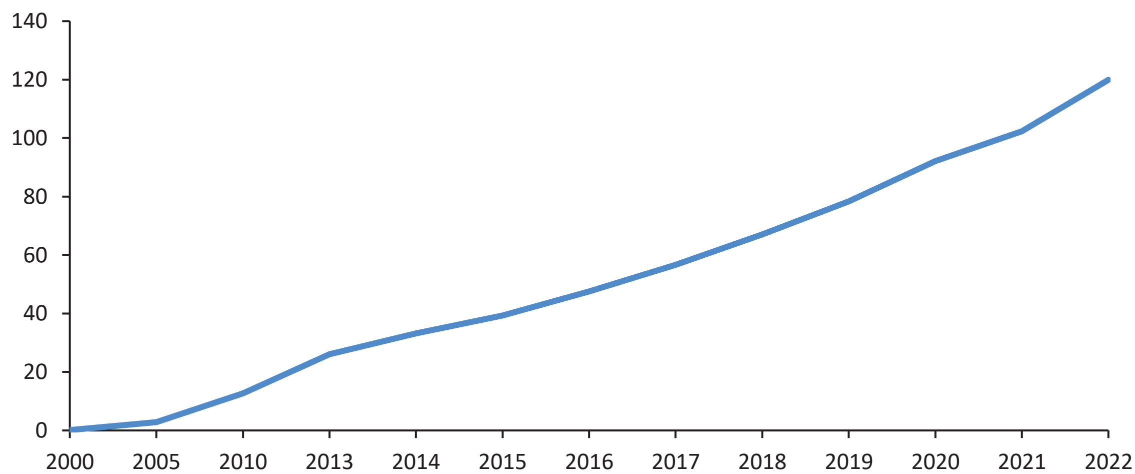
Inventory calculations have been based on the raw trade data (import and export) provided for each gas by Ministry of Trade and the change in emission values are consistent with number of import and export.

A survey was conducted for the years 2020, 2021, and 2022 to analyse HFC consumption in Türkiye on a sector-by-sector basis. Information was gathered from various stakeholders, and customs statistics on bulk HFC import and export were analysed. The survey results will inform project activities under the Montreal Protocol and enable them to be tailored to Türkiye’s specific needs in line with HFC phase-down.

We had productive evaluations with the relevant ERT team during In Country Review process which was held in Ankara, and the efforts made within the scope of this survey were discussed. However, in subsequent efforts, we evaluated that we would not be able to implement the Tier 2 approach of HFC during this submission. This is because the Tier 2 method involves the calculation of Econtainers, Echarge, Elifetime, and Eend-of-life. Türkiye has relevant data for the Econtainers and Echarge, which can be computed using the applicable IPCC default emission factors. However, crucial parameters for the Tier 2 method, namely Elifetime and End-of-life, lack sector-specific data.

Since Türkiye commenced equipment inventory collection in 2023, an inventory for Tier 2 purposes has yet to be established. Consequently, access to equipment data and HFC banks remains severely restricted. Information regarding the amount of HFCs banked in existing systems for Elifetime is unavailable. Furthermore, essential equipment data for End-of-life, including inventory and installation years, is absent in the Country. Without this foundational information, the application of the Tier 2 method to calculate total emissions based on subsectors lacks meaningfulness. The studies in this regard are ongoing, and we remain committed to addressing these challenges.

Figure 4.24 HFC-227ea Emissions (tonnes), 2000-2022



Recalculation:

There is no recalculation for this year's inventory.

Planned Improvement:

No further improvements are planned.

4.8. Other Product Manufacture and Use (Category 2.G)

Source Category Description:

The sub-sector other product manufacture and use consists of the following sub- applications:

- 2.G.1- SF_6 Emissions from electrical equipment

Methodological Issues:

It is assumed that SF_6 is used only in electrical instruments, mainly in circuit breakers. Emission results are reported based on the import and export data of SF_6. However, custom code for this gas was established in 2013 and trade data is available only for 2013-2021. Therefore, trend of electricity consumption is used for the prediction of imported gas for previous years.

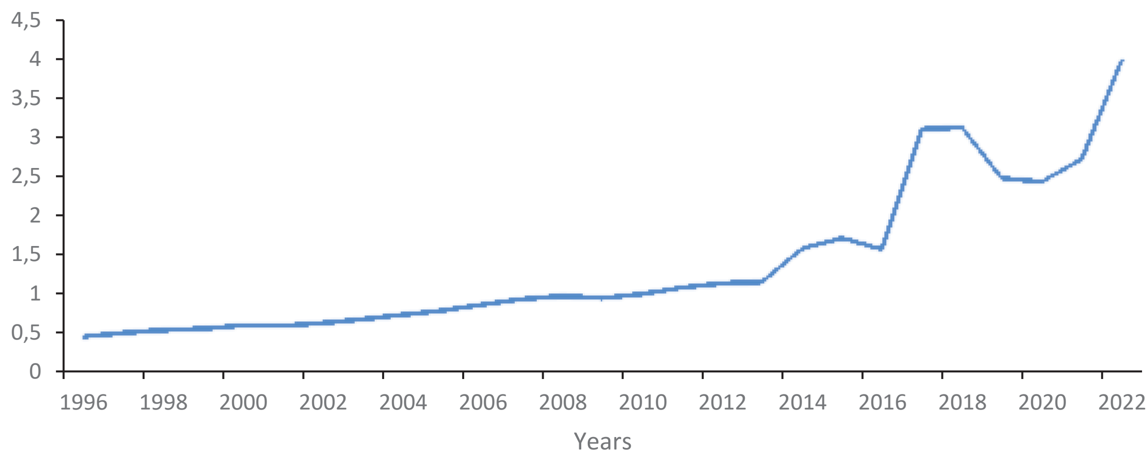
Data for electricity consumption is obtained from the Turkish Electricity Transmission Corporation and the trade data for SF_6 is provided by Ministry of Trade. Table 4.35 shows the distribution of electricity consumption, SF_6 consumption (import and export values) and emissions of SF_6 which is emitted from the circuit breakers used in Electricity industry. The IPCC default values of emission factors (including natural leakage and emissions of operation, maintenance, and disposal) are 2.6% for the EU, 0.7% for Japan, and 2.0% as a global average and calculation made by using the global average value.

There is no information about the number and the capacity of the used, imported or exported equipment and the number of destroyed equipment. The imported gas amount has been assumed as 2% emitted in related year. Import and export data is provided by Ministry of Trade.

Table 4.35 SF_6 Consumption and Electricity Consumption

Years	Electricity consumption (GWh)	SF_6 net consumption (tonnes)	SF_6 Emissions (tonnes)
2000	98 296	29 260	0.585
2005	130 263	38 776	0.775
2010	172 051	49 367	0.987
2011	186 100	55 349	1.070
2012	194 923	56 176	1.123
2013	198 045	57 105	1.142
2014	207 375	78 539	1.571
2015	216 233	85 207	1.704
2016	225 495	78 114	1.562
2017	249 020	155 251	3.105
2018	254 863	156 103	3.122
2019	257 273	123 647	2.473
2020	261 193	121 359	2.427
2021	286 692	135 820	2.716
2022	286 693	199 085	3.982

Figure 4.25 SF_6 emissions, 1996-2022



Uncertainties and Time-Series Consistency:

Uncertainties of SF_6 was estimated using expert judgement as described in IPCC Good Practice Guidance and Uncertainty Management (2000) Reference.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRT tables according to QA/QC plan. Aggregated national EFs are compared with IPCC default values.

Recalculation:

In the last submission, the consumption of SF_6 in Mg production between the years 2016-2021 was accounted in the magnesium production sector. However, the calculation errors covering these years and also the year 2022 were noticed and then corrected.

Additionally, it was noticed that the SF_6 emitted from the electronics industry was not deducted the net imported SF_6 as indicated in the ERT assessment report (ID# I.33). The SF_6 which is emitted between the years 2010-2022 in the electronic industry was included and then corrected.

The next change involves updating the database from the years 2013 to 2022.

Planned Improvement:

No further improvements are planned.

5. AGRICULTURE (CRT Sector 3)

5.1. Sector Overview

Agricultural activities will most likely coexist with the existence of human beings on this planet, and agricultural production is indispensable to the continuance of life. Effects of climate change are observed by concentration of GHGs for many sectors including agriculture which generally comes second in size after the energy sector. The total emission value calculated for the agriculture sector is 71.5 Mt CO_2 eq. for the year 2022 which is 14.2% of the total emission value including the LULUCF sector and 12.8% of all emissions excluding the LULUCF sector for Türkiye. The agricultural sector is divided into ten categories from 3.A to 3.J in the CRT tables. These categories are listed in Table 5.1 briefly for gases emitted from each of these sources.

Table 5.1 Categories of the agriculture sector and emitted gases

CRT Categories		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
3.A	Enteric fermentation		x					
3.B	Manure management		x	x	x[b]		x[b]	
3.C	Rice cultivation		x					
3.D	Agricultural soils	x[a]		x	x[b]		x[b]	
3.E	Prescribed burning of savannas		x	x	x[c]	x[c]	x[c]	x[c]
3.F	Field burning of agricultural residues		x	x	x[b]	x[b]	x[b]	x[b]
3.G	Liming	x						
3.H	Urea application	x						
3.I	Other carbon-containing fertilizers	x						
3.J	Other							

[a] to be reported under LULUCF Sector.
[b] Emissions of this gas from this category are likely to be emitted and a methodology is provided in the EMEP/EEA Guidebook.
[c] Emissions of this air pollutant from this category are likely to be emitted and the methodology may be included in the EMEP/EEA Guidebook in the future.

The percentage of emissions from this sector as percentage of total national GHG emissions (excluding LULUCF) gradually declined from around 23% to 11.2% in most of the years between 1990 and 2009 before levelling off and thereafter gaining momentum. With the aim to give a clear view on the weights of the categories within the sector, the following Table 5.2 presents emission and percentage values for the year 2022.

Table 5.2 Agriculture sector emissions and overall percentages by categories, 2022

	CH_4 (kt CO_2 eq.)	N_2O (kt CO_2 eq.)	CO_2 (kt)	Total (kt CO_2 eq.)	(%)
3 Agriculture	**43 653**	**26 720**	**1 138**	**71 512**	**100.0**
A. Enteric fermentation	38 244			38 244	53.5
B. Manure management	4 983	4 366		9 349	13.1
C. Rice cultivation	280			280	0.4
D. Agricultural soils		22 318		22 318	31.2
E. Prescribed burning of savannas				NO	
F. Field burning of agricultural residues	147	36		182	0.3
G. Liming				NE*	
H. Urea application			1 138	1 138	1.6
I. Other carbon-containing fertilizers				NO	
J. Other				NO	
GHG Percentage Shares	61.0	37.4	1.6	100.0	

*The emission level from source category 3.G Liming is considered to be insignificant according to Decision 18/CMA.1, Annex, paragraph 32.
Figures in the table may not add up to the totals due to rounding.

Table 5.3 clearly presents the developments of the emissions for the agriculture sector. The overall emission value for the agriculture sector increased from approximately 51.8 Mt CO_2 eq. in 1990 to around 71.5 Mt CO_2 eq. in 2022 presenting an increase of 37.9%. The biggest increase among the categories in absolute terms for the emissions is observed in the enteric fermentation category where the emissions increased by around 8.2 Mt CO_2 eq. (27.5%) from 30 Mt CO_2 eq. to 38.2 Mt CO_2 eq. for the same period. The primary reason for this increase is the change in activity data (AD). Other significant increases in this thirty-three years period are seen in agricultural soils, manure management, and urea application where the figures are 6.9 Mt CO_2 eq. (45%), 3.8 Mt CO_2 eq. (69.4%), and 0.7 Mt CO_2 eq. (147%), respectively. Emissions for rice cultivation increased by around 0.2 Mt CO_2 eq. (149.7%) whereas the emissions for field burning of agricultural residues between 1990 and 2022 resulted in a decrease of 50.7%.

Table 5.3 Overview of the agriculture sector emissions, 1990–2022

Year	A. Enteric fermentation (kt CO_2 eq.)	A. Enteric fermentation (%)	B. Manure management (kt CO_2 eq.)	B. Manure management (%)	C. Rice cultivation (kt CO_2 eq.)	C. Rice cultivation (%)	Agriculture total (kt CO_2 eq.)	Agriculture total (%)
1990	29 996	57.9	5 518	10.6	112	0.2	51 848	100
1995	28 298	57.7	5 716	11.7	126	0.3	49 030	100
2000	24 575	53.4	5 334	11.6	143	0.3	46 033	100
2005	25 088	54.2	5 015	10.8	205	0.4	46 266	100
2010	25 498	53.5	5 880	12.3	226	0.5	47 678	100
2011	27 576	54.9	6 086	12.1	229	0.5	50 268	100
2012	30 898	54.9	6 962	12.4	279	0.5	56 258	100
2013	32 048	54.0	7 349	12.4	258	0.4	59 360	100
2014	32 019	53.8	7 693	12.9	257	0.4	59 498	100
2015	31 685	53.5	7 531	12.7	269	0.5	59 208	100
2016	31 617	51.3	7 696	12.5	272	0.4	61 690	100
2017	34 987	52.7	8 412	12.7	262	0.4	66 329	100
2018	37 248	54.1	9 425	13.7	282	0.4	68 910	100
2019	38 608	54.0	9 454	13.2	294	0.4	71 517	100
2020	39 953	52.3	9 934	13.0	293	0.4	76 437	100
2021	40 210	53.3	9 998	13.3	302	0.4	75 376	100
2022	38 244	53.5	9 349	13.1	280	0.4	71 512	100

Figures in the table may not add up to the totals due to rounding.

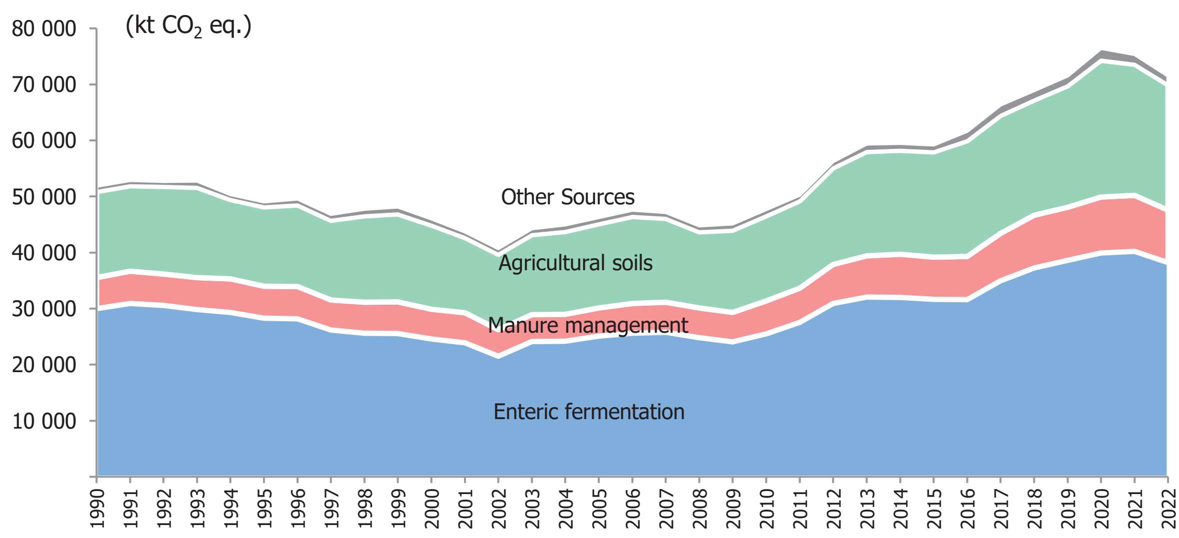
Table 5.3 Overview of the agriculture sector emissions, 1990–2022 (continued)

Year	D. Managed soils (kt CO_2 eq.)	D. Managed soils (%)	F. Field burnıng (kt CO_2 eq.)	F. Field burnıng (%)	H. Urea application (kt CO_2 eq.)	H. Urea application (%)	Agriculture total (kt CO_2 eq.)	Agriculture total (%)
1990	15 391	29.7	370	0.7	460	0.9	51 848	100
1995	14 110	28.8	354	0.7	426	0.9	49 030	100
2000	15 001	32.6	362	0.8	617	1.3	46 033	100
2005	15 023	32.5	322	0.7	613	1.3	46 266	100
2010	15 195	31.9	233	0.5	645	1.4	47 678	100
2011	15 571	31.0	248	0.5	558	1.1	50 268	100
2012	17 241	30.6	238	0.4	640	1.1	56 258	100
2013	18 641	31.4	256	0.4	807	1.4	59 360	100
2014	18 512	31.1	229	0.4	788	1.3	59 498	100
2015	18 728	31.6	185	0.3	811	1.4	59 208	100
2016	20 635	33.4	175	0.3	1 295	2.1	61 690	100
2017	21 043	31.7	176	0.3	1 450	2.2	66 329	100
2018	20 523	29.8	173	0.3	1 257	1.8	68 910	100
2019	21 698	30.3	176	0.2	1 288	1.8	71 517	100
2020	24 417	31.9	183	0.2	1 657	2.2	76 437	100
2021	23 396	31.0	169	0.2	1 302	1.7	75 376	100
2022	22 318	31.2	182	0.3	1 138	1.6	71 512	100

Figures in the table may not add up to the totals due to rounding.

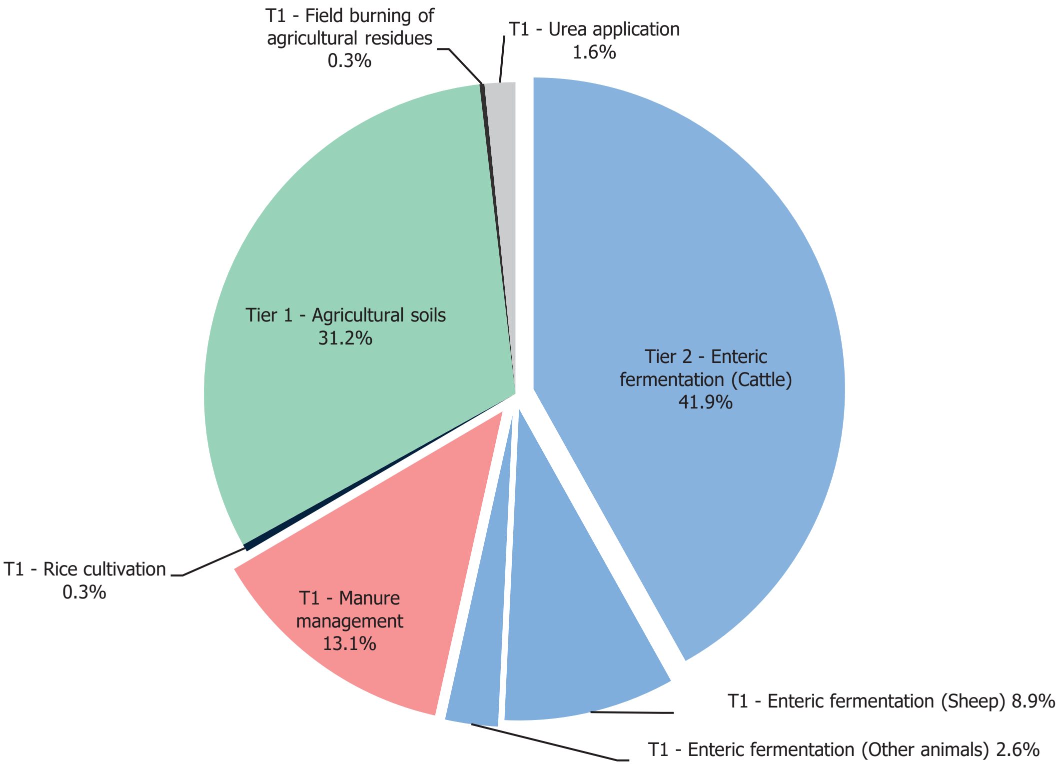
Furthermore, in relative terms, the biggest category in the agriculture sector is enteric fermentation having a 53.5% share for 2022, so it dominates the sector. In all reported years, 1990-2022, this category had an average share of 54.6% in the agriculture sector, starting with a share of 57.9% in 1990. The second biggest category is agricultural soils having a proportion of 31.2% for 2022 decreased from 31% in 2021. While having a percentage share of agricultural soils of 33% in 2002, its average share for the entire reporting period of thirty-three years is around 31.2%. Manure management's share presents somehow a more stable increasing trend, starting from 10.6% in 1990 and reaching 13.1% in 2022 while having an average of 11.9% for all reporting years. For 2022, remaining categories, which are rice cultivation, field burning of agricultural residuals, and urea application, had emission shares of 0.4%, 0.3%, and 1.6%, respectively. Though the share increased by around 81% for rice cultivation and 79.4% for urea application, the absolute terms were small and relative weights of these two categories were low for the reporting period, 1990-2022. Despite these increasing share values, the share for field burning of agricultural residues decreased from 0.7% to 0.3% for the reporting period. A graphical representation is given below in Figure 5.1, which presents the overall cumulative distribution and the trend for the reporting period of the agriculture sector. Other sources are calculated by the summation of emission figures from rice cultivation, field burning, and urea application.

Figure 5.1 Cumulative emissions of agricultural categories, 1990–2022



Additionally, it should be noted that prescribed burning of savannas (CRT Category 3.E) does not occur in Türkiye and is therefore not reported in this National Inventory Document whereas liming (CRT Category 3.G) is considered to be insignificant according to Decision 18/CMA.1, Annex, paragraph 32. The category, other carbon-containing fertilizers (CRT Category 3.I), is not relevant while the final category, other (CRT Category 3.J) in the agriculture sector, is an option to be used only if necessary. Figure 5.2 shows an overview of category shares and methods used for the agriculture sector.

Figure 5.2 Category shares and methods used in the agriculture sector, 2022



The methods used for the emission estimations in the agriculture sector except for cattle in enteric fermentation are Tier 1 (T1). The only Tier 2 (T2) method used in this sector is for emissions due to enteric fermentation of cattle which has a value of 29 952 kt CO_2 eq. This amount equals to around 41.9% of total emissions in the agriculture sector and 78.3% of total emissions in enteric fermentation which is the biggest subcategory in enteric fermentation as presented in Figure 5.2.

Table 5.4 Agriculture sector emissions – comparison between 2021 and 2022

Source Category		2021 (kt CO_2 eq.)	2021 (%)	2022 (kt CO_2 eq.)	2022 (%)	Change (kt CO_2 eq.)	Change (%)
3. Agriculture Sector		**75 376**	**100**	**71 512**	**100**	**-3 865**	**-5.1**
3.A	Enteric Fermentation	40 210	53.3	38 244	53.5	-1 966	-4.9
3.B	Manure Management	9 998	13.3	9 349	13.1	-649	-6.5
3.C	Rice Cultivation	302	0.4	280	0.4	-22	-7.2
3.D	Agricultural Soils	23 396	31.0	22 318	31.2	-1 078	-4.6
3.F	Field Burning	169	0.2	182	0.3	13	7.9
3.H	Urea Application	1 302	1.7	1 138	1.6	-164	-12.6

Figures in the table may not add up to the totals due to rounding. Note that two source categories, CRT 3.E and 3.I, are not occurring (NO), while another source category, CRT 3.G Liming, is not estimated (NE) because it is considered to be insignificant.

The emission values between the latest of two reporting years, 2021 and 2022, are presented in Table 5.4 and in order to present a different perspective on the size changes of major agricultural categories, Figure 5.3 is also given. Major agricultural categories, enteric fermentation, manure management, and agricultural soils, are responsible for more than 97% of the emissions in the sector. Additionally, the main changes in minor agricultural categories are shown in Figure 5.4.

Figure 5.3 Trends in major agriculture categories

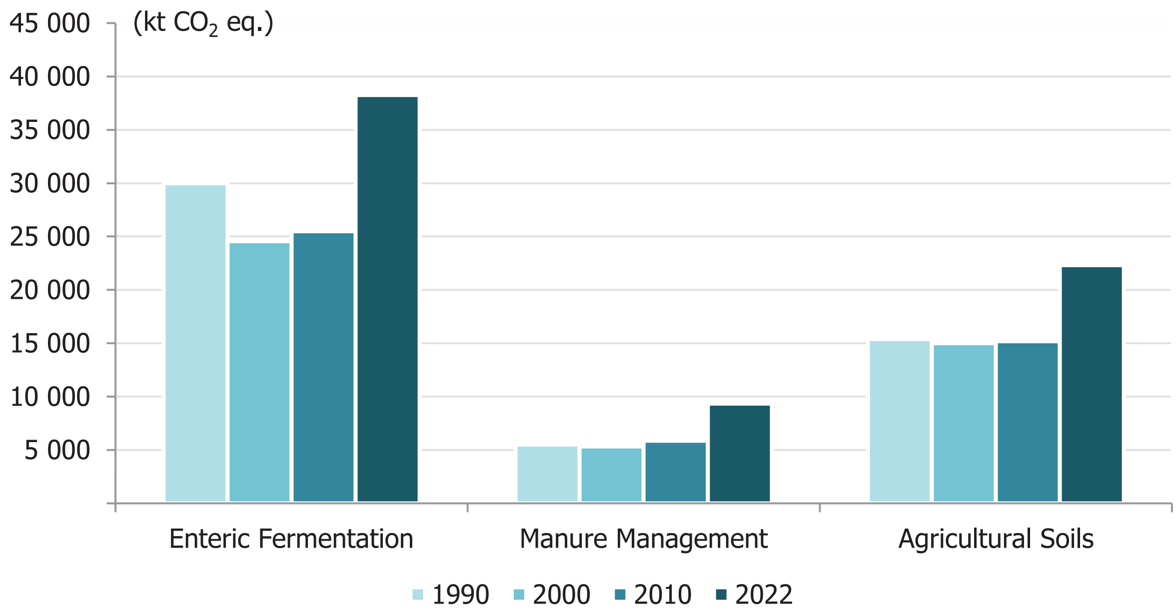
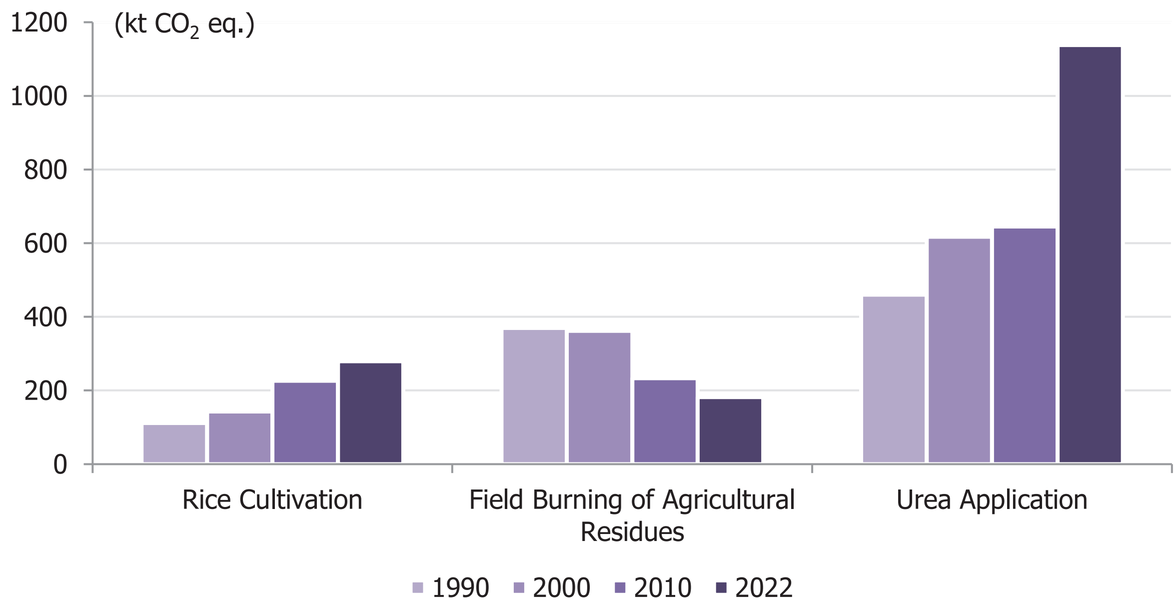


Figure 5.4 Trends in minor agriculture categories



GHG emission values and their percentage shares in the agriculture sector, CH_4, N_2O and CO_2, are presented in Table 5.5. After its initial increase in 1991, emission values for CH_4 decreased in the twelve years until 2002. Thereafter, the main trend changed into an increasing one presenting decreases for a few years as well. But, overall, the percentage share of CH_4 decreased from 64% in 1990 to 61% in 2022.

The average share of N_2O emissions were around 36.9% with respect to yearly total agricultural emission values. The emission values for N_2O were 18 207 kt CO_2 eq. (35.1%) in 1990 and increased to an estimated value of 26 720 kt CO_2 eq. while taking a share of 37.4% of total agricultural emissions in 2022, the latest reporting year. N_2O emissions are due to manure management and agricultural soils source categories in the agricultural sector.

CO_2 emissions result only from urea application; have the smallest share in this sector, and ranges between 0.8% and 2.2% for the period 1990-2022. The highest absolute value of CO_2 emissions occurred in 2020 with 1 657 kt, while it has the smallest value in 1995 with 426 kt depending on the amount of urea applied. The corresponding value for the latest reporting year accounts for a share of 1.6%.

Table 5.5 Overview of GHGs in the agriculture sector, 1990–2022

	CH_4		N_2O		CO_2		Total
Year	**(kt CO_2 eq.)**	**(%)**	**(kt CO_2 eq.)**	**(%)**	**(kt)**	**(%)**	**(kt CO_2 eq.)**
1990	33 181	64.0	18 207	35.1	460	0.9	51 848
1995	31 759	64.8	16 845	34.4	426	0.9	49 030
2000	27 846	60.5	17 570	38.2	617	1.3	46 033
2005	28 056	60.6	17 596	38.0	613	1.3	46 266
2010	29 195	61.2	17 839	37.4	645	1.4	47 678
2011	31 257	62.2	18 454	36.7	558	1.1	50 268
2012	35 140	62.5	20 478	36.4	640	1.1	56 258
2013	36 507	61.5	22 046	37.1	807	1.4	59 360
2014	36 681	61.7	22 030	37.0	788	1.3	59 498
2015	36 143	61.0	22 254	37.6	811	1.4	59 208
2016	36 215	58.7	24 180	39.2	1 295	2.1	61 690
2017	39 935	60.2	24 945	37.6	1 450	2.2	66 329
2018	42 986	62.4	24 667	35.8	1 257	1.8	68 910
2019	44 249	61.9	25 980	36.3	1 288	1.8	71 517
2020	45 826	60.0	28 954	37.9	1 657	2.2	76 437
2021	46 061	61.1	28 013	37.2	1 302	1.7	75 376
2022	43 653	61.0	26 720	37.4	1 138	1.6	71 512

Figures in the table may not add up to the totals due to rounding. Source categories for CH_4 and N_2O emissions are presented in Table 5.9 and 5.10, respectively, whereas the only source category for CO_2 emissions is urea application (CRT category 3.H) which emits carbon dioxide reported under the agriculture sector.

The activity data used for the compilation of the GHG inventory are provided mainly by TurkStat's databases distributed by its Central Dissemination System on the following website accessible on https://biruni.tuik.gov.tr/medas/?kn=101&locale=en which is also accessible at www.turkstat.gov.tr.

Data on livestock production have been collected from District Offices of the Ministry of Agriculture and Forestry at the end of the year. Since 2014, data on livestock numbers have been collected and published two times a year. The data, entered into an online database by the district offices, have been analyzed together with the Ministry of Agriculture and Forestry. Prepared data are sent to the Ministry for controlling process. Once again controlled data are analyzed by Agricultural Production Statistics Group at TurkStat and will then become ready for publishing after final analysis and controls.

Livestock population numbers are given for livestock species in Table 5.6. As the numbers show, both dairy and non-dairy cattle, domestic sheep, poultry and goats have significantly high population numbers with respect to other livestock species. Six columns, which are dairy cattle, non-dairy cattle, domestic sheep, merino sheep, goats, and poultry, have positive differences between 1990 and 2022 with population increasing around 0.5 million (8.6%), 5.0 million (90.5%), 1.0 million (2.6%), 3.1 million (370.2%), 0.7 million (6%) and 264.3 million (258.5%), respectively. It is remarkable that poultry numbers had more than tripled in 33 years from around 102.3 million to over 366 million. Contrary to these developments, the change for the reporting period of 33 years was as much as -86.3% for the swine population and -91.1% for mules and asses. Similarly, other changing percentages observed for camels, buffalo, and horses are -40.4%, -53.7%, and -85.5%, respectively. The figures also presents a decreasing trend for few livestock species for the reporting period of 1990-2022. During the reporting period, our country's population is increasingly living in urban areas rather than in rural areas which reduced the demand for some of the animals in small households living in rural areas. Moreover, a few animal categories used for carrying goods previously in rural areas, are not needed any more extensively for this purpose. Thus the demand for some of the livestock species decreased.

Table 5.6 Livestock population numbers in Türkiye, 1990–2022

(thousand)

Year	Dairy Cattle	Non-Dairy Cattle	Sheep Domestic	Sheep Merino	Goats	Buffalo	Horses	Mules and Asses	Swine, Camels	Poultry
1990	5 893	5 485	39 711	842	10 926	371	513	1 187	14.0	102 255
1995	5 886	5 903	32 985	806	9 111	255	415	900	7.0	135 251
2000	5 280	5 481	27 719	773	7 201	146	271	588	4.0	264 451
2005	3 998	6 528	24 552	752	6 517	105	208	423	2.7	322 917
2010	4 362	7 008	22 003	1 086	6 293	85	155	260	2.8	238 973
2011	4 761	7 625	23 811	1 221	7 278	98	151	248	3.1	241 499
2012	5 431	8 484	25 893	1 533	8 357	107	141	236	4.3	257 505
2013	5 607	8 808	27 485	1 799	9 226	118	136	227	4.5	270 202
2014	5 609	8 614	29 034	2 106	10 345	122	131	212	4.1	298 030
2015	5 536	8 458	29 302	2 206	10 416	134	123	198	3.2	316 332
2016	5 432	8 648	28 833	2 151	10 345	142	120	190	2.9	333 541
2017	5 969	9 975	31 257	2 420	10 635	161	114	176	3.1	348 144
2018	6 338	10 705	32 513	2 682	10 922	178	108	165	3.3	359 218
2019	6 581	11 107	34 199	3 077	11 205	184	102	156	3.1	348 785
2020	6 775	11 190	38 580	3 547	11 986	192	90	133	2.0	386 081
2021	6 759	11 091	41 183	3 995	12 342	186	84	118	2.6	398 115
2022	6 402	10 450	40 729	3 959	11 578	172	74	105	2.8	366 584

Note that dairy cattle population for the year 2003 is taken as the average of population figures for 2002 and 2004 after carefully discussed/scrutinized with the Agricultural Statistics Department at TurkStat in order to ensure comparability for the entire time series. This was necessary because of a different methodology applied regarding dairy cattle for the year 2003. Non-dairy cattle figures were adjusted accordingly.

Time series for cattle population with its subcategories in our country are presented in Table 5.7. Livestock production can result in CH_4 emissions from enteric fermentation and also in CH_4 and N_2O emissions from livestock manure management systems. Cattle as a livestock category is a significant source of CH_4 in our country because of their large population and high CH_4 emission rate due to their ruminant digestive system.

In Türkiye there are three dairy cattle types categorized as culture cattle, hybrid cattle and domestic cattle as shown in Table 5.8. Culture dairy cattle is a dairy cattle type having higher milk yields compared to domestic dairy cattle whereas milk yields values of hybrid cattle are between them. Hybrid cattle are breeds of culture and domestic dairy cattle. Culture dairy cattle population is increasing by years except for the years 1997, 1998, 2002-2004 and 2021-2022. But, in general, the culture dairy cattle population has a positive trend in the period 1990-2022, which has a percentage increase of 41% from 9% in 1990 to 50% in 2022 within dairy cattle population. For hybrid cattle population, which was around 2.7 million in 2022 despite being 1.9 million in 1990, a big increase or decrease in percentage share cannot be observed throughout the same period, though the final four reporting years identified first a total increase of around 0.1 million followed by a similar amount of decrease. The share of domestic cattle among dairy cattle was 58.1% in 1990 but this ratio reduced to 7.4% in 2022. As seen in Table 5.7, non-dairy cattle number increased by approximately 5.6 million from around 5.5 million in 1990 to more than 10.5 million in 2022 and its share in total number of cattle increased from 48.2% to 62% between

1990 and 2022. Furthermore, Figure 5.5 presents three types of dairy cattle as well as non-dairy cattle population numbers for the period of 1990-2022 in a straightforward chart.

Figure 5.5 Population numbers for cattle categories, 1990–2022

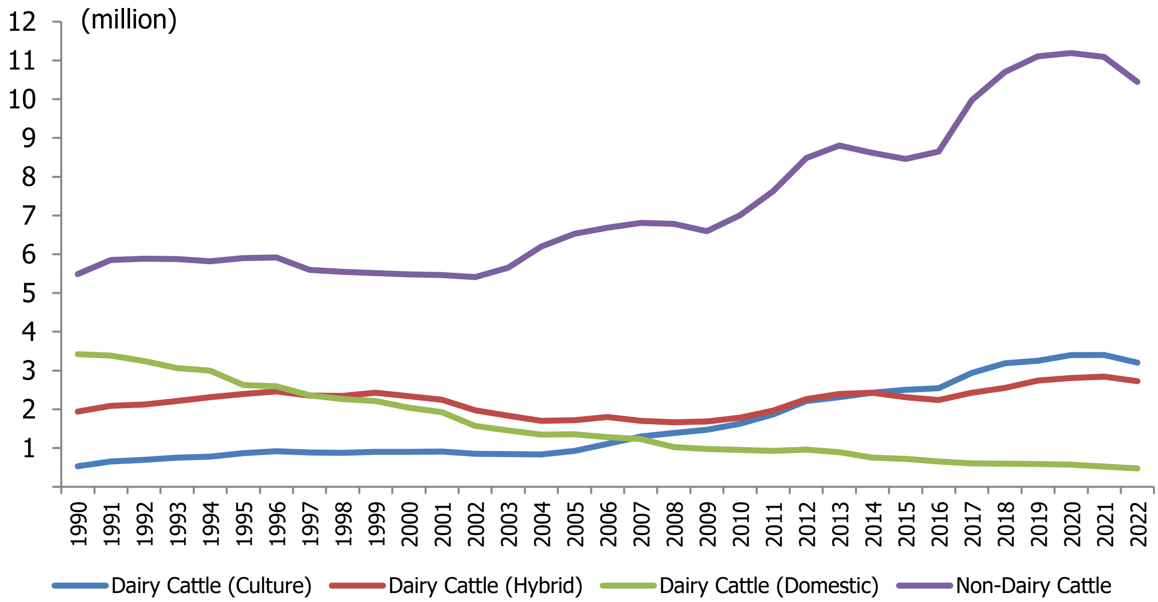


Table 5.7 Subcategories of cattle population, 1990–2022

(thousand)

Year	Total Cattle	Dairy Cattle		Non-Dairy Cattle	
	(population)	(population)	(%)	(population)	(%)
1990	11 377	5 893	51.8	5 485	48.2
1995	11 789	5 886	49.9	5 903	50.1
2000	10 761	5 280	49.1	5 481	50.9
2005	10 526	3 998	38.0	6 528	62.0
2010	11 370	4 362	38.4	7 008	61.6
2011	12 386	4 761	38.4	7 625	61.6
2012	13 915	5 431	39.0	8 484	61.0
2013	14 415	5 607	38.9	8 808	61.1
2014	14 223	5 609	39.4	8 614	60.6
2015	13 994	5 536	39.6	8 458	60.4
2016	14 080	5 432	38.6	8 648	61.4
2017	15 944	5 969	37.4	9 975	62.6
2018	17 043	6 338	37.2	10 705	62.8
2019	17 688	6 581	37.2	11 107	62.8
2020	17 965	6 775	37.7	11 190	62.3
2021	17 851	6 759	37.9	11 091	62.1
2022	16 852	6 402	38.0	10 450	62.0

Figures in the table may not add up to the totals due to rounding. Note also the footnote to Table 5.6.

Table 5.8 Subcategories of dairy cattle population, 1990–2022

(thousand)

Year	Total	Culture		Hybrid		Domestic	
	(population)	(population)	(%)	(population)	(%)	(population)	(%)
1990	5 893	530	9.0	1 941	32.9	3 421	58.1
1995	5 886	870	14.8	2 393	40.7	2 623	44.6
2000	5 280	905	17.1	2 335	44.2	2 040	38.6
2005	3 998	926	23.2	1 717	43.0	1 355	33.9
2010	4 362	1 626	37.3	1 787	41.0	948	21.7
2011	4 761	1 868	39.2	1 963	41.2	930	19.5
2012	5 431	2 211	40.7	2 263	41.7	957	17.6
2013	5 607	2 314	41.3	2 396	42.7	897	16.0
2014	5 609	2 428	43.3	2 429	43.3	753	13.4
2015	5 536	2 501	45.2	2 314	41.8	721	13.0
2016	5 432	2 542	46.8	2 236	41.2	654	12.0
2017	5 969	2 941	49.3	2 427	40.7	601	10.1
2018	6 338	3 186	50.3	2 555	40.3	597	9.4
2019	6 581	3 249	49.4	2 745	41.7	587	8.9
2020	6 775	3 398	50.2	2 808	41.4	569	8.4
2021	6 759	3 398	50.3	2 842	42.0	519	7.7
2022	6 402	3 201	50.0	2 727	42.6	474	7.4

Figures in the table may not add up to the totals due to rounding. Note also the footnote to Table 5.6.

Table 5.3, given previously, presents a detailed perspective on the agriculture sector emissions for the reporting period. GHG emissions from livestock are CH_4 in enteric fermentation and CH_4 and N_2O in manure management. Rice cultivation leads to CH_4 emissions, agricultural soils to N_2O emissions, field burning of crop residues to CH_4 and N_2O emissions. Urea application is the only category directly resulting in CO_2 emissions reported under the agriculture sector in our country. An overview of emission factors and parameters related to emission calculations from the agriculture sector is shown in Annex 4 of the NID.

Methane (CH_4)

Emissions from enteric fermentation, manure management, rice cultivation and field burning of agricultural residues include methane. The agriculture sector in our country produced 1559 kt CH_4 (43.7 Mt CO_2 eq.) emissions, which equals 61% of agricultural emissions or 60.5% of Türkiye's CH_4 emissions (without LULUCF), or 7.8% of Türkiye's total emissions in 2022. CH_4 emissions had increased by 10 472 kt CO_2 eq. (31.6%) from its 1990 level of 33 181 kt CO_2 eq. to 43 653 kt CO_2 eq. in 2022. This increase is mainly a result of increases in CH_4 emissions from enteric fermentation of 8 247 kt CO_2 eq., from manure management of 2 207 kt CO_2 eq., and from rice cultivation of 168 kt CO_2 eq. The total increase as high as 10 472 kt CO_2 eq. is responsible for 53.3% of 19 664 kt CO_2 eq. overall increase in emissions from the agricultural sector between 1990 and 2022.

Enteric fermentation is the single dominant category leading to 90.4% in 1990 and 87.6% in 2022 of all CH_4 emissions of the agriculture sector. Enteric fermentation was followed by manure management with 8.4% in 1990 and 11.4% in 2022. CH_4 emissions from field burning of agricultural residues are 0.9% in 1990 and 0.3% in 2022 of all CH_4 emissions from the agriculture sector. CH_4 emissions share of rice cultivation is 0.3% and 0.6% for 1990 and 2022, respectively. An overview of CH_4 emissions are presented in the following table.

Table 5.9 Overview of CH_4 emissions in the agriculture sector, 1990–2022

	CH_4 Emissions								
	3.A		3.B		3.C		3.F		Total
Year	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)
1990	29996	90.4	2776	8.4	112	0.3	297	0.9	33 181
1995	28298	89.1	3051	9.6	126	0.4	284	0.9	31 759
2000	24575	88.3	2837	10.2	143	0.5	291	1.0	27 846
2005	25088	89.4	2505	8.9	205	0.7	259	0.9	28 056
2010	25498	87.3	3283	11.2	226	0.8	187	0.6	29 195
2011	27576	88.2	3252	10.4	229	0.7	199	0.6	31 257
2012	30898	87.9	3772	10.7	279	0.8	191	0.5	35 140
2013	32048	87.8	3995	10.9	258	0.7	206	0.6	36 507
2014	32019	87.3	4221	11.5	257	0.7	184	0.5	36 681
2015	31685	87.7	4040	11.2	269	0.7	149	0.4	36 143
2016	31617	87.3	4185	11.6	272	0.8	141	0.4	36 215
2017	34987	87.6	4544	11.4	262	0.7	141	0.4	39 935
2018	37248	86.7	5315	12.4	282	0.7	139	0.3	42 986
2019	38608	87.3	5206	11.8	294	0.7	141	0.3	44 249
2020	39953	87.2	5433	11.9	293	0.6	147	0.3	45 826
2021	40210	87.3	5414	11.8	302	0.7	136	0.3	46 061
2022	38244	87.6	4983	11.4	280	0.6	147	0.3	43 653

Figures in the table may not add up to the totals due to rounding.

Nitrous Oxide (N_2O)

Nitrous oxide is a GHG with a high global warming potential. Overall, excluding LULUCF, N_2O emissions accounted for around 6.1% of Türkiye's GHG emissions in 2022. Emissions from manure management, agricultural soils, and field burning of agricultural residues include N_2O gas. Agriculture as a sector produced 100.83 kt N_2O emissions (26.7 Mt CO_2 eq.), which equals 37.4% of agricultural emissions or 77.9% of Türkiye's N_2O emissions (excluding LULUCF) or 4.8% of Türkiye's total emissions in 2022. N_2O emissions from the agriculture sector have increased by 8 513 kt CO_2 eq. (46.8%) from 18 207 kt CO_2 eq. (1990) to 26 720 kt CO_2 eq. (2022).

The source category agricultural soils is the dominant source of N_2O emissions, responsible for 84.5% and 83.5% of total agricultural N_2O emissions for the years 1990 and 2022, respectively. Regarding N_2O emissions, agricultural soils were followed by manure management with 15.1% in 1990 and 16.3% in 2022, and field burning of agricultural residues with 0.4% in 1990 and 0.1% in 2022. While a percentage as high as 81.4% of the augmentation in nitrous oxide emissions is a result of increases of N_2O emissions in agricultural soils by 6 927 kt CO_2 eq., manure management is responsible for the remaining increase of 19.1% with 1 624 kt CO_2 eq. in N_2O emissions. N_2O emissions of field burning of agricultural residues show a decrease of 50.7% by an amount of 37 kt CO_2 eq., which equals 0.4% of the changes in agricultural N_2O emissions between 1990 and 2022. The net increase of 8 513 kt CO_2 eq. of N_2O

emissions added up to 43.3% of the overall increase of 19 664 kt CO_2 eq. emissions in the agriculture sector between 1990 and 2022. An overview of N_2O emissions is presented in the next table.

Table 5.10 Overview of N_2O emissions in the agriculture sector, 1990–2022

	N_2O Emissions						
	3.B		3.D		3.F		Total
Year	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)
1990	2 743	15.1	15 391	84.5	73	0.4	18 207
1995	2 665	15.8	14 110	83.8	70	0.4	16 845
2000	2 498	14.2	15 001	85.4	71	0.4	17 570
2005	2 510	14.3	15 023	85.4	63	0.4	17 596
2010	2 597	14.6	15 195	85.2	46	0.3	17 839
2011	2 834	15.4	15 571	84.4	49	0.3	18 454
2012	3 190	15.6	17 241	84.2	47	0.2	20 478
2013	3 355	15.2	18 641	84.6	50	0.2	22 046
2014	3 473	15.8	18 512	84.0	45	0.2	22 030
2015	3 490	15.7	18 728	84.2	37	0.2	22 254
2016	3 511	14.5	20 635	85.3	35	0.1	24 180
2017	3 867	15.5	21 043	84.4	35	0.1	24 945
2018	4 110	16.7	20 523	83.2	34	0.1	24 667
2019	4 247	16.3	21 698	83.5	35	0.1	25 980
2020	4 501	15.5	24 417	84.3	36	0.1	28 954
2021	4 584	16.4	23 396	83.5	33	0.1	28 013
2022	4 366	16.3	22 318	83.5	36	0.1	26 720

Figures in the table may not add up to the totals due to rounding.

5.2. Enteric Fermentation (Category 3.A)

Source Category Description:

Enteric fermentation is a digestive process whereby carbohydrates are broken down by micro-organisms into simple molecules. The main product is CH_4 gas. Animals produce CH_4 during and/or after feed intake. The largest source of CH_4 emissions in the agricultural sector in our country is enteric fermentation. It is the biggest source of total carbon dioxide equivalent emissions in the agriculture sector with 57.9% (30 Mt CO_2 eq.) in 1990 and with 53.5% (38.2 Mt CO_2 eq.) in 2022.

In 2022, enteric fermentation contributed as high as 38 244 kt CO_2 eq., responsible for more than half of agricultural emissions as stated above and 6.9% of Türkiye's total CO_2 eq. emissions. Dairy and non-dairy cattle contributed 29 952 kt CO_2 eq. (78.3%) of emissions to the enteric fermentation category and sheep (domestic and merino) contributed 6 338 kt CO_2 eq. (16.6%) of emissions to this category. This source category in 2022 resulted in a value of 8 244 kt CO_2 eq. (27.5%) of increased emissions compared to 1990 levels (29 996 kt CO_2 eq).

CH_4 emissions from enteric fermentation, which are presented by main livestock species in Table 5.11, fluctuate over time. This source category is a key category according to level and trend assessment. Enteric fermentation emissions declined by 28.3% (8.5 Mt CO_2 eq.) between 1990 and 2002. The decline in emissions in the early 1990s was primarily occurred by a fall in cattle and sheep numbers; however, the emissions had begun to increase as the numbers of cattle began to rise by late 2004, reflecting changing relative returns to each industry. Due to governmental support, the numbers of many significant livestock species have been increasing in recent years, thereby resulting also in an increase in CH_4 emissions for these subcategories. Between 2004 and 2022, emissions from enteric fermentation increased by 58% (14 Mt CO_2 eq).

There have been changes in the relative sources of emissions within enteric fermentation (Table 5.11) since 1990. The largest increase occurred from non-dairy cattle emissions basically due to an increase in its population numbers. In 2022, non-dairy cattle were responsible for 14 580 kt CO_2 eq., increased by 5 481 kt CO_2 eq. (60.2%) from the 1990 level of 9 100 kt CO_2 eq. Despite a slight increase of 8.6% in dairy cattle population for the period of 1990-2022, this subcategory is responsible for 15 372 kt CO_2 eq. in 2022, still an increase of 2 865 kt CO_2 eq. (22.9%) above its 1990 level of 12 508 CO_2 eq. Population numbers of livestock species for the period 1990-2022 are shown in Table 5.6. While Figure 5.6 presents the percentage shares for the subcategories of enteric fermentation emission sources for the latest reporting year, Table 5.11 presents CH_4 emissions of enteric fermentation regarding livestock species for the period, 1990-2022.

Figure 5.6 Enteric Fermentation Emission Sources, 2022

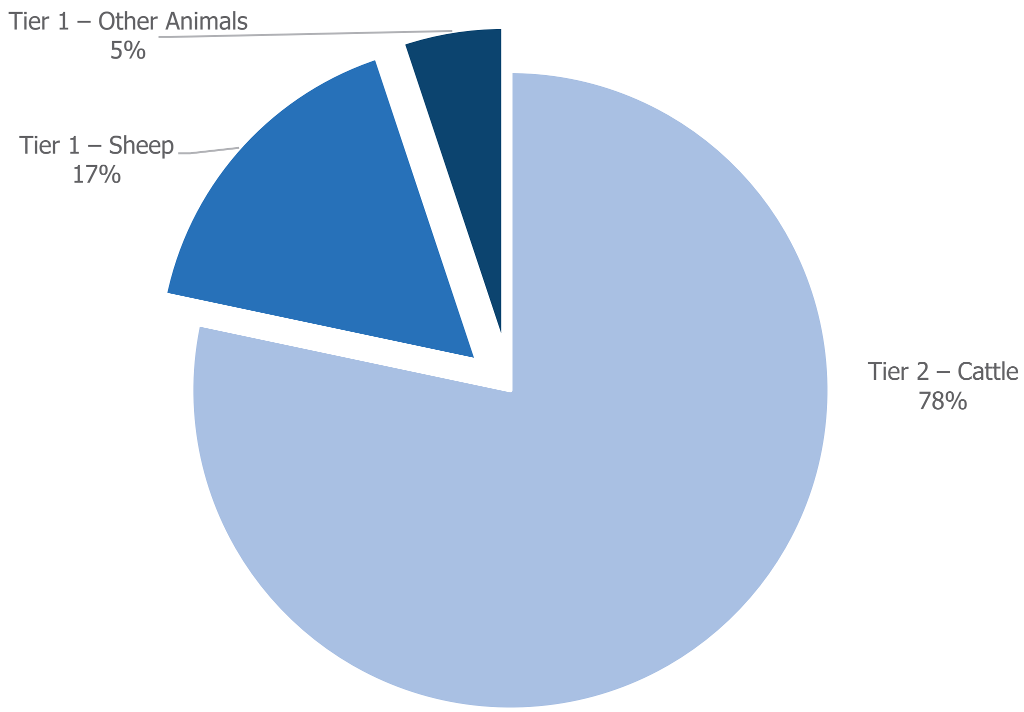


Table 5.11 Enteric fermentation CH_4 emissions, 1990–2022

(kt CO_2 eq.)

Year	Dairy Cattle	Non-Dairy Cattle	Sheep Domestic	Sheep Merino	Goats	Buffalo	Horses	Mules and Asses	Swine, Camels	Total
1990	12 508	9 100	5 560	135	1 530	571	259	332	3	29 996
1995	12 398	9 021	4 618	129	1 276	393	209	252	3	28 298
2000	11 049	7 986	3 881	124	1 008	225	137	165	1	24 575
2005	9 472	10 760	3 437	121	912	162	105	118	1	25 088
2010	10 449	10 630	3 080	174	881	130	78	73	2	25 498
2011	11 409	11 322	3 334	196	1 019	150	76	69	2	27 576
2012	13 012	12 541	3 625	246	1 170	165	71	66	2	30 898
2013	13 409	12 895	3 848	289	1 292	181	69	64	2	32 048
2014	13 414	12 438	4 065	338	1 448	188	66	59	2	32 019
2015	13 289	12 156	4 102	354	1 458	206	62	55	2	31 685
2016	13 063	12 389	4 037	345	1 448	219	61	53	2	31 617
2017	14 379	13 997	4 376	388	1 489	249	57	49	2	34 987
2018	15 280	15 080	4 552	430	1 529	275	54	46	2	37 248
2019	15 817	15 559	4 788	494	1 569	284	52	44	2	38 608
2020	16 296	15 628	5 401	569	1 678	296	45	37	2	39 953
2021	16 245	15 468	5 766	641	1 728	286	42	33	2	40 210
2022	15 372	14 580	5 702	635	1 621	265	37	30	2	38 244

Figures in the table may not add up to the totals due to rounding.

Methodological Issues:

Türkiye applies T1 method to estimate CH_4 emissions from enteric fermentation for all livestock populations except cattle for which T2 method is applied. The T2 method is applied by using mainly country-specific parameters. Necessary data for T2 calculations are mainly gathered from TurkStat Agricultural Statistics Department, Ministry of Agriculture and Forestry, academic sources. The results for cattle in enteric fermentation are presented both in Figure 5.6 and Table 5.11. Moreover, Tables 5.12 and 5.13 present key country-specific parameters regarding T2 calculation; except for methane conversion factor which is a default value shown in the 2006 IPCC Guidelines. The annual population numbers for livestock species are included in Table 5.6 above. The AD (the population of livestock species) are obtained from TurkStat livestock statistics. TurkStat collects livestock data as explained in the sector overview. T2 cattle emissions are calculated according to equations 10.3, 10.4, 10.6, 10.8, 10.13, 10.14, 10.15, 10.16 and 10.21 presented in the 2006 IPCC Guidelines, Volume 4, Chapter 10.

Sheep are categorized as merino and domestic sheep in our country. For domestic sheep IPCC default EF for developing countries (5.0 kg CH_4 head^{-1} year^{-1}) is used. Merino sheep are also a kind of domestic sheep fed for their wool. The weight of merino sheep is higher compared to domestic sheep and their feeding rate is also higher than domestic ones. The country-specific typical animal mass values are 50 kg/head and 60 kg/head for domestic sheep and merino sheep, respectively. The approximate EF for merino sheep is 5.73 kg CH_4/head/year obtained by the quotient of the weight figures (60 kg/50kg) raised to the power of 0.75 and then multiplied by the EF for domestic sheep (5.0 kg CH_4 head^{-1} year^{-1}). As a result, the EF for merino sheep is taken as 5.73 kg CH_4/head/year while the EF for domestic sheep is taken as the IPCC default EF for developing countries (5.0 kg CH_4 head^{-1} year^{-1}).

Uncertainties and Time-Series Consistency:

The AD for this sector are gathered from agricultural statistics of TurkStat. Uncertainties for the activity data are determined by TurkStat experts and uncertainty values for EFs are taken from the IPCC Guidelines. The calculated AD uncertainty figure is 8.82% whereas the EF uncertainty value is 12.03% figured out by using Equation 3.2 in the IPCC Guidelines Vol. 1.

Source category	Gas	Comments on time series consistency
3.A	CH_4	All EFs for cattle are not constant over the entire time series because they are estimated mainly according to the split of culture, hybrid and domestic. Since the population numbers for cattle change over the reporting period, the respective EFs also reflect this change. EFs for all other livestock species are constant.

Source-Specific QA/QC and Verification:

The 2006 IPCC Guidelines are used for the QA/QC procedures of the National GHG emission inventory. The National Inventory System QA/QC Plan prepared by TurkStat is a significant tool for implementing QA/QC procedures for the Inventory. AD for this source category are gathered mainly from the Agricultural Statistics Department of TurkStat. The respective AD used for calculations are published also as official statistics by TurkStat which have their own QA/QC procedures. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculations are re-examined.

Recalculation:

Revisions are a result of an update in the EF used for merino sheep and of updates in feed digestibility coefficients for cattle. For emissions from cattle of this source category , the revision percentage is 29.6% (176.1 kt CH_4) for 1990 and 3.8% (41 kt CH_4) for 2021 with an average increasing effect of 15.1% for the period 1990-2021. For emissions from merino sheep of this source category, the revision percentage is -11.8% for the entire period, 1990-2021, with an average decreasing effect of 1.07 kt CH_4.

Table 5.12 Key T2 parameters and estimated emissions for dairy cattle, 1990–2022

	Dairy Cattle					
Year	CH_4 Emissions (kt CO_2 eq.)	Mass (kg)	GE intake (MJ/head/day)	CH_4 Conversion rates, Y_m (%)	Milk yield (kg/day)	Digestibility of feed (%)
1990	12 508	350.4	177.8	6.50	3.70	57.23
1995	12 398	377.4	176.5	6.50	4.32	60.20
2000	11 049	389.0	175.3	6.50	4.53	61.50
2005	9 472	404.1	198.5	6.50	6.87	62.54
2010	10 449	440.9	200.7	6.50	7.80	65.22
2011	11 409	446.8	200.7	6.50	7.94	65.70
2012	13 012	451.5	200.7	6.50	8.06	66.12
2013	13 409	454.6	200.3	6.50	8.14	66.48
2014	13 414	461.0	200.3	6.50	8.30	67.05
2015	13 289	464.2	201.1	6.50	8.38	67.14
2016	13 063	467.9	201.5	6.50	8.47	67.35
2017	14 379	474.1	201.8	6.50	8.61	67.78
2018	15 280	476.4	202.0	6.50	8.66	67.93
2019	15 817	475.9	201.3	6.50	8.65	68.04
2020	16 296	477.7	201.5	6.50	8.69	68.15
2021	16 245	478.9	201.3	6.50	8.73	68.31
2022	15 372	478.9	201.2	6.50	8.74	68.37

Table 5.13 Key T2 parameters and estimated emissions for non-dairy cattle, 1990–2022

	Non-Dairy Cattle				
Year	CH_4 Emissions (kt CO_2 eq.)	Mass (kg)	GE intake (MJ/head/day)	CH_4 Conversion rates, Y_m (%)	Digestibility of feed (%)
1990	9 100	180.6	139.0	6.50	55.26
1995	9 021	192.3	128.0	6.50	57.89
2000	7 986	194.5	122.0	6.50	58.91
2005	10 760	253.9	138.1	6.50	61.17
2010	10 630	279.2	127.1	6.50	63.74
2011	11 322	281.2	124.4	6.50	64.07
2012	12 541	287.5	123.8	6.50	64.51
2013	12 895	289.0	122.6	6.50	64.73
2014	12 438	293.6	121.0	6.50	65.17
2015	12 156	296.4	120.4	6.50	65.30
2016	12 389	297.6	120.0	6.50	65.52
2017	13 997	296.4	117.6	6.50	65.90
2018	15 080	300.1	118.0	6.50	66.10
2019	15 559	300.1	117.3	6.50	66.17
2020	15 628	304.5	117.0	6.50	66.26
2021	15 468	305.2	116.8	6.50	66.43
2022	14 580	307.8	116.9	6.50	66.58

Planned Improvement:

All data and methodologies are kept under review.

5.3. Manure Management (Category 3.B)

Source Category Description:

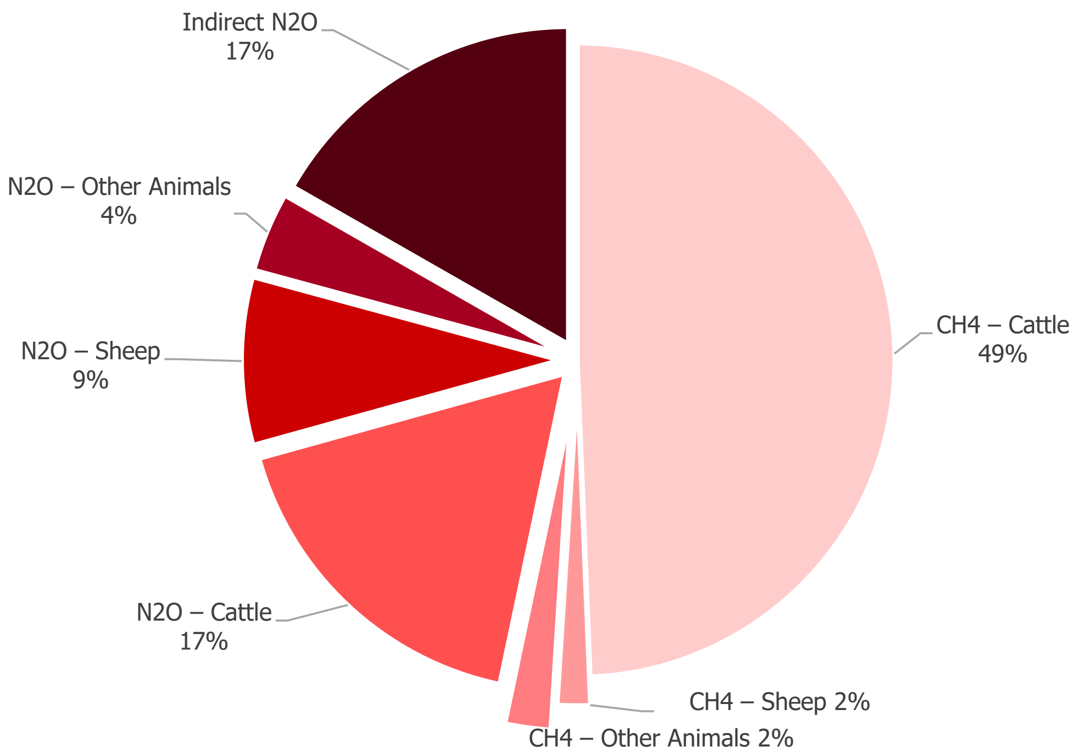
In Türkiye, manure management systems (MMS) distribution data are a result of the combination of various sources, including expert opinions, comparison of countries in the Mediterranean basin, MoAF data, TurkStat data etc. resulting in a country-specific MMS distribution presented in Table 5.19.

This source category contains two types of emissions, CH_4 and N_2O, and for both of these emissions, the source category is a key category according to level assessment. According to trend assessment, while the source category is key category only for N_2O emissions with LULUCF, it is also key category for N_2O and CH_4 emissions without LULUCF.

In 2022, emissions including CH_4 and N_2O from the manure management category reached 9 349 kt CO_2 eq. This number represented 13.1% of emissions of the agriculture sector. Emissions from this source category in 2022 increased by 3 831 kt CO_2 eq., nearly 69.4% above its 1990 level of 5 518 kt CO_2 eq. Similarly, the increase is calculated as 2 207 kt CO_2 eq. for CH_4 emissions and 1 624 kt CO_2 eq. for N_2O emissions and increasing percentages are 80% and 59%, respectively, for the period 1990-2022.

Manure management emissions can also be described as direct emissions consisting of CH_4 and N_2O emissions with a share of 83.3% (7 785 kt CO_2 eq.) and indirect emissions consisting only of N_2O emissions with a share of 16.7% (1 565 kt CO_2 eq.). It is also significant to note that there are two types of indirect N_2O emissions to be calculated under manure management, which are due to nitrogen volatilization and nitrogen leaching and run-off. The indirect N_2O emissions share of 16.7% is only a result of the amount of manure nitrogen that is lost due to volatilization of NH_3 and NO_x. Indirect emissions due to leaching and run-off from manure are calculated as 135 kt CO_2 eq. for the latest reporting year. This emission level is considered insignificant and reported as NE according to Decision 18/CMA.1, Annex, paragraph 32. While the following Figure 5.7 presents emission shares of manure management subcategories for the latest reporting year, Table 5.11 combines and presents the emission figures from manure management for the entire reporting period.

Figure 5.7 Manure Management Emission Sources, 2022



Regarding MMS, TurkStat has asked academicians for their views on the topic, investigated countries in the Mediterranean Basin whose the agriculture sector would resemble of our country's, searched internally through some of our regional offices, looked for field experiences gained throughout the years within TurkStat and also scrutinized agriculture-related data which have not been published so far in order to come up with a distribution that would reflect our country-specific conditions better.

Table 5.14 Overview of emissions from manure management, 1990–2022

		Manure management source category							
	Agriculture Total	Total		CH_4		Direct N_2O		Indirect N_2O	
Year	(kt CO_2 eq.)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)
1990	51 848	5 518	10.6	2 776	5.4	1 947	3.8	796	1.5
1995	49 030	5 716	11.7	3 051	6.2	1 843	3.8	823	1.7
2000	46 033	5 334	11.6	2 837	6.2	1 632	3.5	865	1.9
2005	46 266	5 015	10.8	2 505	5.4	1 559	3.4	950	2.1
2010	47 678	5 880	12.3	3 283	6.9	1 646	3.5	951	2.0
2011	50 268	6 086	12.1	3 252	6.5	1 808	3.6	1 026	2.0
2012	56 258	6 962	12.4	3 772	6.7	2 041	3.6	1 149	2.0
2013	59 360	7 349	12.4	3 995	6.7	2 150	3.6	1 204	2.0
2014	59 498	7 693	12.9	4 221	7.1	2 223	3.7	1 249	2.1
2015	59 208	7 531	12.7	4 040	6.8	2 226	3.8	1 265	2.1
2016	61 690	7 696	12.5	4 185	6.8	2 224	3.6	1 286	2.1
2017	66 329	8 412	12.7	4 544	6.9	2 454	3.7	1 414	2.1
2018	68 910	9 425	13.7	5 315	7.7	2 605	3.8	1 505	2.2
2019	71 517	9 454	13.2	5 206	7.3	2 707	3.8	1 540	2.2
2020	76 437	9 934	13.0	5 433	7.1	2 867	3.8	1 634	2.1
2021	75 376	9 998	13.3	5 414	7.2	2 927	3.9	1 658	2.2
2022	71 512	9 349	13.1	4 983	7.0	2 802	3.9	1 565	2.2

Indirect N_2O emissions from manure management include only emissions due to atmospheric deposition. Manure management indirect N_2O emissions due to leaching and run-off are considered to be insignificant because of its calculated emission level of 135 kt CO_2 eq. for the latest reporting year. This level is well-below the threshold level specified in Decision 18/CMA.1, Annex, paragraph 32. The indirect N_2O emissions level from nitrogen leaching and run-off is estimated by applying Equations 10.28 and 10.29 (Chapter 10, Volume 4, 2006 IPCC Guidelines). Given our country's rather dry climatic conditions, a FracLeachMS value of 4.5% is used in the calculations for all solid storage and dry lot manure systems as appropriate. 4.5% is the mid-range value between 3% and 6% which is considered to be more suitable in drier climates as explained on page 10.56 of the 2006 IPCC Guidelines. Figures in the table may not add up to the totals due to rounding.

Methane Generation

Livestock manure is primarily composed of organic material and water. Anaerobic and facultative bacteria decompose the organic material under anaerobic conditions. Several biological and chemical factors influence methane generation from manure. The amount of CH_4 produced during decomposition is influenced by the climate and the manner in which the manure is managed. The management system determines key factors that affect CH_4 production including contact with oxygen, water content, pH, and nutrient availability. Climate factors include temperature and rainfall. Optimal conditions for CH_4 production include an anaerobic, water-based environment, a high level of nutrients for bacterial growth, a neutral pH (close to 7.0), warm temperatures, and a moist climate.

Manure management CH_4 emissions contributed 4 983 kt CO_2 eq. (53.3% of the manure management category) which constituted 7% of agricultural emissions in 2022 whereas the respective share in 1990 was 5.4%, around 1.6 per cent below the current reporting value.

With respect to all CH_4 emissions of the agriculture sector, the second highest CH_4 emission source category was manure management for all reporting years with a share value of 8.4% and 11.4% for 1990 and 2022, respectively, and an average share value of 10.2% for the reporting period, 1990-2022.

Nitrous Oxide Generation

Production of N_2O reported in the manure management category occurs during storage and treatment of manure before it is applied to land.

N_2O emissions contributed 4 366 kt CO_2 eq. (46.7% of the manure management category) which represented 6.1% of agricultural emissions in 2022 whereas the respective share in 1990 was 5.3%, less than the current percentage of 2022.

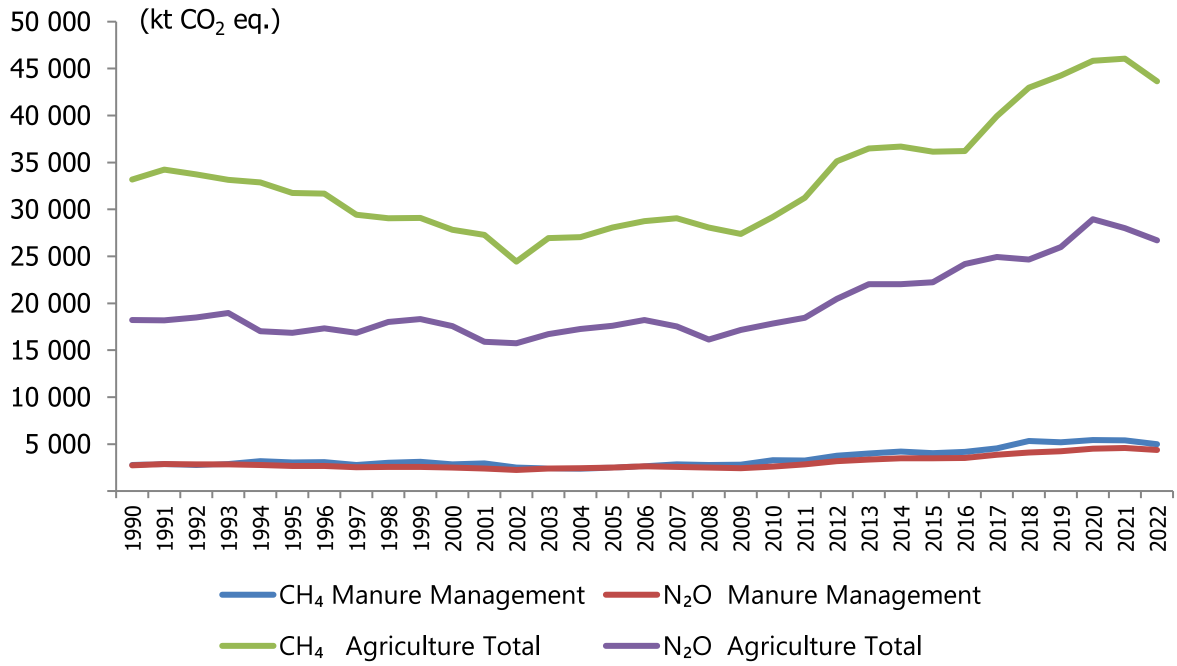
With respect to all N_2O emissions of the agriculture sector, the second highest N_2O emission source category was manure management after agricultural soils category for all reporting years. N_2O emissions of manure management accounted for 15.1% and 16.3% of all N_2O emissions in the agriculture sector in 1990 and 2022, respectively.

Direct N_2O emissions from MMS can occur via combined nitrification (under aerobic conditions) and denitrification (an anaerobic process) of nitrogen contained in the manure. The emission of N_2O from manure during storage and treatment depends on the nitrogen and carbon content of manure, on the duration of the storage and type of treatment.

Indirect N_2O emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NO_x. Indirect emissions occur from the deposition of volatilized nitrogen from manure management systems and via runoff and leaching of nitrogen into soils.

The following figure on CH_4 and N_2O emissions of manure management and the agriculture sector gives a view on tendencies. As indicated above, CH_4 and N_2O from manure management are only a fraction of total CH_4 and N_2O emissions from the agriculture sector, 11.4% and 16.3%, respectively, in 2022 and therefore these are not a key driver in the overall trends in the agriculture sector. However, the trends for these gases in this category generally reflect the overall trend of the same gases in the agriculture sector. Figure 5.8 shows a trend comparison of these two gas emissions.

Figure 5.8 Comparing CH_4 and N_2O emission trends, 1990–2022



Typical animal mass values, Nrates and Nitrogen excretion rates (Nex) are crucial parameters in estimating emissions from manure management. Table 5.15 and Table 5.16 present these values for animal categories for the entire reporting period, 1990-2022.

Table 5.15 Typical animal mass, Nrate and Nex values for cattle and poultry, 1990–2022

Year	Dairy Cattle Mass (kg)	Dairy Cattle Nrate[a]	Dairy Cattle Nex[b]	Non-dairy Cattle Mass (kg)	Non-dairy Cattle Nrate[a]	Non-dairy Cattle Nex[b]	Poultry Mass (kg)	Poultry Nrate[a]	Poultry Nex[b]
1990	350.4	0.47	60.38	180.6	0.34	22.41	2.22	0.81	0.65
1995	377.4	0.47	65.12	192.3	0.34	23.87	2.14	0.81	0.63
2000	389.0	0.47	67.15	194.5	0.34	24.14	2.02	0.81	0.60
2005	404.1	0.47	69.79	253.9	0.34	31.51	2.18	0.81	0.65
2010	440.9	0.47	76.25	279.2	0.34	34.64	2.28	0.81	0.68
2011	446.8	0.47	77.27	281.2	0.34	34.90	2.30	0.82	0.68
2012	451.5	0.47	78.10	287.5	0.34	35.67	2.29	0.82	0.68
2013	454.6	0.47	78.64	289.0	0.34	35.87	2.30	0.82	0.68
2014	461.0	0.47	79.77	293.6	0.34	36.43	2.30	0.82	0.68
2015	464.2	0.47	80.33	296.4	0.34	36.79	2.28	0.82	0.68
2016	467.9	0.47	80.97	297.6	0.34	36.93	2.28	0.82	0.68
2017	474.1	0.47	82.06	296.4	0.34	36.78	2.29	0.81	0.68
2018	476.4	0.47	82.47	300.1	0.34	37.24	2.32	0.81	0.69
2019	475.9	0.47	82.37	300.1	0.34	37.25	2.34	0.81	0.70
2020	477.7	0.47	82.69	304.5	0.34	37.79	2.36	0.81	0.70
2021	478.9	0.47	82.90	305.2	0.34	37.87	2.36	0.81	0.70
2022	478.9	0.47	82.90	307.8	0.34	38.19	2.34	0.82	0.70

All mass values are live weight figures and these figures are country-specific. Country-specific figures for cattle are gathered from a variety of sources including the Ministry for Agriculture and Forestry and TurkStat data. Country-specific poultry mass data ara gathered from the Ministry for Agriculture and Forestry.

[a] Unit for Nrate is kg N/ (1000 kg animal mass × day).

[b] Unit for Nex is kg N/ (head × yr).

Table 5.16 Typical animal mass, Nrate and Nex values for some livestock species

Years	Livestock species	Mass (kg)	Nrate[b]	Nex (kg N/head/yr)
1990 – 2022	Sheep (domestic)	50	1.17	21.35
1990 – 2022	Sheep (merino)	60	1.01	22.12
1990 – 2022	Goats	45	1.37	22.50
1990 – 2022	Buffalo	380	0.32	44.38
1990 – 2022	Horses	238	0.46	39.96
1990 – 2022	Mules & Asses	130	0.46	21.83
1990 – 2022	Swine[a]	28	0.402	4.11
1990 – 2022	Camels	217	0.46	36.43

All mass figures are live weight figures. Mass values given for sheep (domestic and merino) and goats were country-specific values. Mass values given for buffalo, horses, swine, camels, and mules & asses were all default values presented in the 2006 IPCC Guidelines Vol.4.

[a] According to the footnote given on page 10.59, Table 10.19 of the 2006 IPCC Guidelines Vol.4 Chapter 10, nitrogen excretion for swine is based on an estimated country population of 90% market swine and 10% breeding swine. Thus, the Nrate is calculated as given and used in the related Nex calculation: (90% × 0.42)+(10% × 0.24)=0.402 (Nrate value for swine).

[b] Unit for Nrate is kg N/ (1000 kg animal mass × day).

Methodological Issues:

Türkiye applies T1 method according to the 2006 IPCC Guidelines to estimate methane and nitrous oxide emissions from manure management for all livestock types. CH_4 and N_2O emissions from manure management are key category according to level assessment.

The annual population for each livestock category is included in Table 5.6 above. The AD (the population of animals) provider is the Turkish Statistical Institute for the entire time series, 1990-2022. TurkStat collects livestock data as explained in the Sector Overview. In addition, our country uses the national animal population numbers and allocates the population for each animal subcategory into cool, temperate and warm climate regions in the following manner. First, the animal population numbers are listed according to their respective provinces in our country. Second, all provinces are allocated to one of the three mentioned climate regions concerning their yearly average temperature values. Finally, all population numbers of each animal subcategory within each of the climate regions, namely cool, temperate and warm, are added up before calculating the weighted average with respect to population numbers of the total animal subcategory.

The CH_4 EFs are default IPCC T1 factors except for cattle. In Türkiye, there are three dairy cattle types categorized as culture cattle, hybrid cattle and domestic cattle. For 2022, the average milk production of culture cattle is around 3 864 kg head^{-1} yr^{-1}. Hence, the EF for culture cattle is taken as the average of EFs of Western Europe and Asia with respect to milk yield of these cattle, and the mean of milk production of Western Europe (6 000 kg head^{-1} yr^{-1}) and Asia (1 650 kg head^{-1} yr^{-1}) is 3 825 kg head^{-1} yr^{-1}. In a similar manner, domestic cattle's EF was taken as Asia EF, and hybrid cattle's EF is taken as the average of culture and domestic cattle EF. The average milk production of domestic cattle is 1 299 kg head^{-1} yr^{-1} and this value is closer to the Asia average milk production value of 1 650 kg head^{-1} yr^{-1}. The average milk production of Hybrid cattle is 2 726 kg head^{-1} yr^{-1} and this value is close to the mean of 3 825 and 1 650 kg head^{-1} yr^{-1} which is 2 737 kg head^{-1} yr^{-1}. Furthermore, domestic dairy cattle have almost similar properties with Asian cattle like milk yield. Since the T1 method regarding cattle still applies for agricultural categories other than enteric fermentation, the explanation given is still valid for other agricultural categories like manure management.

In order to select appropriate EFs, animal population data, collected from TurkStat databases, are categorized according to their provinces with respective annual temperature figures. CH_4 and N_2O emission factors are default 2006 IPCC T1 factors.

The annual average temperatures of the provinces are taken into account in order to select the EFs for manure management. All temperature data are taken directly from the General Directorate of Meteorology. Table 5.17 presents default EFs based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Vol.4 for cattle types and swine for each region according to temperature classification. Considering annual average air temperature, provinces are categorized between cool (0ºC - 14ºC) and temperate (15ºC - 25ºC) climate region. Similar to the methods applied in enteric fermentation, the IPCC default emission factors selected for cattle were based on the IPCC default factors for Western Europe and Asia (see Table 10.14, Vol.4 of the 2006 IPCC Guidelines). The EF for domestic cattle is assumed to be similar with cattle in Asia because their milk yield values are similar. The EF for culture cattle was estimated as the mean of the emission factors for dairy cattle from Western Europe and Asia, for the same temperature zone (e.g., at <10º C Türkiye estimates that culture cattle have an EF of 15 kg CH_4/head/year, which is the average of 21 kg CH_4/head/year and 9 kg CH_4/head/year from Western Europe and Asia, respectively). The EF for hybrid cattle is the mean of domestic and culture cattle. EF values for non-dairy cattle are determined similarly to the approach taken for dairy cattle.

For swine, the EFs for Asia from the 2006 IPCC Guidelines (Table 10.14 of Volume 4, Chapter 10) were selected, because of similar body weights.

The EFs for sheep and other livestock, shown in the 2006 IPCC Guidelines, are also broken into two climate regions and shown in Table 5.18. Türkiye does not have a province with an annual average temperature above 25°C; therefore, the warm climate region does not exist in the country.

Table 5.17 Manure management CH_4 emission factors for cattle and swine

(kg CH_4/head/year)

	Cool EF (< 15 °C)					Temperate EF (15-25 °C)										
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1. Cattle																
Dairy Cattle (Culture)	15.0	16.5	17.5	19.0	20.5	23.5	25.5	27.5	29.5	32.0	34.5	37.5	40.0	43.5	47.0	50.5
Dairy Cattle (Hybrid)	12.0	13.3	13.8	15.0	16.3	18.3	19.8	21.3	22.8	24.5	26.3	28.8	30.5	33.3	35.5	38.3
Dairy Cattle (Domestic)	9	10	10	11	12	13	14	15	16	17	18	20	21	23	24	26
Non-dairy Cattle (Culture)	3.5	4.0	4.0	4.5	4.5	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.5	11.0
Non-dairy Cattle (Hybrid)	2.25	2.5	2.5	2.75	2.75	3.25	3.5	3.75	4.0	4.25	4.5	4.75	5.0	5.25	5.75	6.0
Non-dairy Cattle (Domestic)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3. Swine	2	2	2	2	2	3	3	3	3	4	4	4	5	5	5	6

Table 5.18 Manure management CH_4 emission factors for sheep and other livestock

(kg CH_4/head/year)

	Cool EF (< 15 °C)	Temperate EF (15-25 °C)
2. Sheep		
Sheep (Domestic)	0.100	0.150
Sheep (Merino)	0.145	0.215
4. Other livestock		
Buffalo	1.00	2.00
Camels	1.28	1.92
Goats	0.11	0.17
Horses	1.09	1.64
Mules and asses	0.60	0.90
Poultry	0.01	0.02

Furthermore, Table 5.19 presents the Manure Management System (MMS) used according to country-specific values. These figures are able to reflect Türkiye's conditions in an improved way leading to improved emission estimations. Note also that 50% of burned manure is reported under the Energy sector category 1.A.4.b – fuel combustion activities (residential), while the remaining 50% is calculated and reported under pasture, range and paddock according to the rules given under section 10.5.2 of the 2006 IPCC Guidelines, Vol.4.

Table 5.19 Manure Management System Distribution, 1990–2022

(%)

MS	Liquid system	Solid storage	Dry lot	Pasture, range and paddock	Burned for fuel or as waste	Poultry manure
Dairy Cattle (Culture)	10.0	50.0	6.0	30.0	4.0	
Dairy Cattle (Hybrid)	10.0	50.0	6.0	30.0	4.0	
Dairy Cattle (Domestic)	10.0	50.0	6.0	30.0	4.0	
Non-Dairy Cattle	10.0	50.0	6.0	30.0	4.0	
Swine				96.0	4.0	
Sheep (Domestic)		40.0		60.0		
Sheep (Merino)		40.0		60.0		
Buffalo		60.0	6.0	30.0	4.0	
Camels		40.0		60.0		
Horses		25.0	15.0	60.0		
Goats		10.0	10.0	80.0		
Mules and Asses		25.0	15.0	60.0		
Chickens				20.0		80.0
Ducks & Geese				100.0		
Turkeys				20.0		80.0

Note that "Other" shown in the CRT Tables relates entirely to poultry manure. Anaerobic lagoon, daily spread, composting and digesters (four different MMS types) were considered as either not occurring or negligible. Definite data on MMS are not available and the table was prepared in order to serve the estimations for CRT 3.B source category based on a variety of data sources.

Uncertainties and Time-Series Consistency:

The approach to produce quantitative uncertainty estimates was used as described in the 2006 IPCC Guidelines for determining uncertainties of that category in total emissions.

The AD for this sector are gathered from agricultural statistics of TurkStat. Uncertainties for activity data are determined by TurkStat experts and uncertainty values for EFs are taken from the IPCC Guidelines. The calculated AD uncertainty figure is 14.1% both for CH_4 and N_2O gases whereas EF uncertainty values are 30% and 50% for CH_4 and N_2O gases, respectively, as presented in the 2006 IPCC Guidelines.

Source category	Gas	Comments on time series consistency
3.B	CH_4, N_2O	CH_4 EFs are selected according to the yearly mean temperature values of the 81 provinces. N_2O EFs are mainly constant over the entire time series except for cattle (dairy & other) and poultry which reflect the weighted average of their subcategories over the reporting period.

Source-Specific QA/QC and Verification:

The 2006 IPCC Guidelines were used for the QA/QC procedures of National GHG emission inventory. A National Inventory System QA/QC Plan prepared by TurkStat is also a significant tool for implementing QA/QC principles for the Inventory. AD for this source category are gathered mainly from the Agricultural Statistics Department of TurkStat. The respective AD, used for calculations, are also published as official statistics by TurkStat which have their own QA/QC procedures. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined.

Recalculation:

Revisions are a result of a major improvement in the selection of emission factors for non-dairy cattle methane emissions. The division of culture-hybrid-domestic cattle used in the selection of emission factors for dairy cattle is also applied to non-dairy cattle in this submission. For non-dairy cattle emissions from this source category, the average increasing revision amount is 15.5 kt CH_4 (198.7%) for the period 1990-2021, while increased revision amounts are 5 kt CH_4 and 33.8 kt CH_4 for 1990 and 2021, respectively.

Planned Improvement:

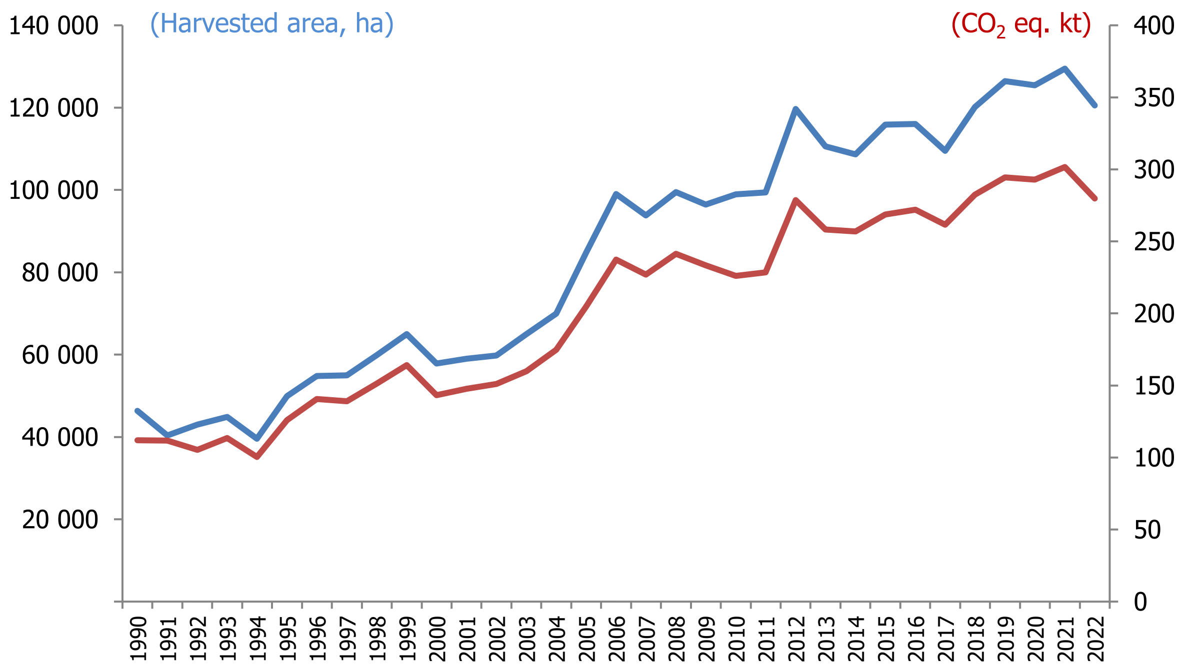
All data and methodologies are kept under review. A tier 2 method cannot be applied currently due to insufficient country-specific data for significant livestock category.

5.4. Rice Cultivation (Category 3.C)

Source Category Description:

GHG emissions from rice production are the result of the CH_4 gas released by anaerobic digestion of organic substances in the paddy fields. The aforementioned CH_4 gas emissions are calculated according to the approach shown in the 2006 IPCC Guidelines which are estimated by IPCC's default emission factors. The annual amount of CH_4 emitted from a given area of rice is a function of the number and duration of crops grown, water regimes before and during the cultivation period, and organic and inorganic soil amendments. Soil type, temperature, fertilizer application, rice cultivar also affect CH_4 emissions. CH_4 emissions from rice cultivation are not a key category. Figure 5.9 presents total annual harvested area in hectare (line drawn in blue - left axis) and total methane emissions emitted in CO_2 eq. kt (line drawn in dark red - right axis) for rice cultivation covering the period 1990-2022.

Figure 5.9 Harvested area and emitted CH_4 for rice cultivation, 1990–2022



Rice cultivation contributed nearly 10 kt CH_4 (279.9 kt CO_2 eq.) emissions or 0.39% of total agricultural emissions in 2022 whereas the respected value for the year 1990 was around 4 kt CH_4 (112.1 kt CO_2 eq.) emissions or 0.22% of total sector emissions.

Overall, emissions from rice cultivation increased by 167.8 kt CO_2 eq. (149.7%) for the entire reporting period while the share of emissions from this source category increased by around 81% from 0.22% to 0.39% of sector emissions.

Table 5.20, given below, presents the activity data and estimated emissions of this source category in detail.

Table 5.20 Irrigated area and estimated emissions for rice cultivation, 1990–2022

	Total		Continuously Flooded		Intermittently Flooded			
					Single Aeration		Multiple Aeration	
Year	(kt CO_2 eq.)	Area (ha)	(kt CO_2 eq.)	Area (ha)	(kt CO_2 eq.)	Area (ha)	(kt CO_2 eq.)	Area (ha)
1990	112.09	46 348	58.06	17 276	18.01	8 693	36.02	20 379
1995	126.01	49 955	70.39	21 203	18.72	8 434	36.90	20 318
2000	143.32	57 859	79.74	24 800	22.87	10 694	40.71	22 365
2005	204.94	84 909	107.58	32 926	39.25	18 949	58.11	33 034
2010	226.11	98 966	96.58	29 856	44.57	21 900	84.96	47 210
2011	228.57	99 383	104.97	32 456	43.62	21 449	79.97	45 479
2012	278.78	119 664	134.76	41 613	49.61	24 647	94.42	53 405
2013	258.20	110 592	125.03	38 670	46.42	23 018	86.74	48 905
2014	256.90	108 649	128.34	39 628	50.62	25 395	77.94	43 626
2015	268.63	115 856	129.60	40 057	46.56	23 355	92.47	52 444
2016	271.97	116 056	135.14	41 763	47.93	23 912	88.90	50 381
2017	261.69	109 505	136.43	42 153	47.71	23 778	77.55	43 575
2018	282.49	120 137	140.14	43 178	51.34	25 606	91.01	51 353
2019	294.40	126 419	143.07	44 053	51.46	25 817	99.87	56 549
2020	292.91	125 398	142.89	43 942	52.73	26 551	97.30	54 905
2021	301.65	129 475	145.65	44 740	54.19	27 206	101.81	57 530
2022	279.87	120 511	133.76	40 726	52.72	26 669	93.39	53 116

Figures in the table may not add up to the totals due to rounding.

Methodological Issues:

Harvested area data for rice cultivation are taken from TurkStat agricultural statistics and area records are available for all districts of Türkiye since 1990. T1 method is used for calculation, and the emission factor and scaling factors are taken from the 2006 IPCC Guidelines. The cultivation period of rice production in Türkiye is around 130 days. The methods mainly used in our country includes continuously flooded, intermittently flooded with single aeration and intermittently flooded with multiple aeration. Accordingly, disaggregated case parameters are used for these methods from the 2006 IPCC Guidelines. Initially, the required data are gathered from TurkStat's regional offices. Mainly based on these data, in addition to data received from the Ministry of Agriculture and Forestry, values of scaling factors according to the 2006 IPCC Guidelines are determined for both SF_w and SF_p parameters. Due to the large geographical diversity of our country, all values for disaggregated scaling factors are used. Moreover, information on cultivation period for rice production is also obtained from regional offices of TurkStat and all different periods are taken into account. The default CH_4 baseline emission factor (EF_c) applied is 1.30 CH_4/ha/day for rice cultivation emission calculations, a non-key category, under T1 method. Organic amendments are not used or, if any, used in negligible amounts. This, in turn, reduces the value of the related scaling factor (SF_o) to 1, a multiplicative identity, given by Equation 5.3 on page 5.50 of the 2006 IPCC Guidelines Vol.4. Furthermore, scaling factors ($SF_{s,r}$) for other related variables are not available, and as a result not used, which is in line with the information provided on page 5.48 presented in the 2006 IPCC Guidelines Vol.4. Accordingly, emissions from this source category are calculated and reported taking into account the country-specific conditions.

Uncertainties and Time-Series Consistency:

The AD for this sector are gathered from agricultural statistics of TurkStat, and the information about water regime, water regime prior to rice cultivation and cultivation periods, which are crucial in determining appropriate scaling factors, are obtained from regional offices of TurkStat for all provinces and their districts in Türkiye. The AD for this sector are gathered from agricultural statistics of TurkStat and the related AD uncertainty figure is considered to be 5%. Uncertainty value for the EF is calculated as 76.76% according to the information shown in the 2006 IPCC Guidelines.

Source category	Gas	Comments on time series consistency
3.C	CH_4	EFs reflect the subcategories of the methods applied for rice cultivation. The calculations reflect different types of water regimes applied in the country. A list of EFs and related parameters used for emission calculations are listed in Annex 4 of the National Inventory Document.

Source-Specific QA/QC and Verification:

The 2006 IPCC Guidelines were used for the QA/QC procedures of National GHG emission inventory. A National Inventory System QA/QC Plan prepared by TurkStat is also a significant tool for implementing QA/QC principles for the Inventory. AD for this source category are mainly gathered from the Agricultural Statistics Department of TurkStat. The respective AD, used for calculations, are also published as official statistics by TurkStat which have their own QA/QC procedures. Emission trends are analyzed.

Recalculation:

There was no recalculation exercised regarding emission estimates from this source category in this submission.

Planned Improvement:

All data and methodologies are kept under review. There are no further planned improvements in this source category.

5.5. Agricultural Soils (Category 3.D)

Source Category Description:

This source, which is a key category, contains N_2O emissions from synthetic fertilizers, organic fertilizers and crop residues. In this section N_2O emissions from pasture, range and paddock manure, cultivation of organic soils, and indirect emissions, which consist of atmospheric deposition and nitrogen leaching and run-off, are estimated too. The complete time series regarding emissions are submitted in this submission. While direct N_2O emissions from this source category are key category according to the level and trend assessment (with and without LULUCF), indirect N_2O emissions from this source category are key categories only according to the level (without LULUCF) and trend assessment (with and without LULUCF).

Agriculture soils produced 84.2 kt N_2O (22.3 Mt CO_2 eq.) emissions in 2022 and agriculture soils is the largest source category of N_2O emissions in Türkiye. This figure represented 83.5% of N_2O emissions in the Agriculture sector, around 65.1% of Türkiye's N_2O emissions (without LULUCF), and around 31.2% of agricultural emissions. In 2022 - the latest reporting year - emissions were 6 927 kt CO_2 eq. (45%) above the 1990 level of 15 391 kt CO_2 eq. Direct N_2O emissions increased by 6 300 kt CO_2 eq. (46.7%) whereas indirect N_2O emissions increased by 627 kt CO_2 eq. (33%) for the given period 1990-2022. The increase is a result of the emission changes of direct and indirect N_2O emissions from managed soils. The total change of direct N_2O emissions is a result of emission increases in the subcategories inorganic N fertilizers, organic N fertilizers, urine and dung deposited by grazing animals, crop residues, and also soil organic matter loss.

Several subcategories contribute to emissions from agricultural soils from direct and indirect pathways (Tables 5.21 – 5.24). Direct N_2O emissions occur directly from the soils to which N has been added or released; indirect emissions arise from volatilization (evaporation or sublimation) and subsequent redeposition of NH_3 or NO_x or result from leaching and runoff of soil N within water (IPCC, 2006). A precise overview is also presented in Figure 5.10 and Table 5.21 for direct and indirect N_2O emissions. The abbreviations used in this figure are listed on the headings of Tables 5.22 and 5.24.

Figure 5.10 Sub-categories of Agricultural Soils Emission Sources, 2022

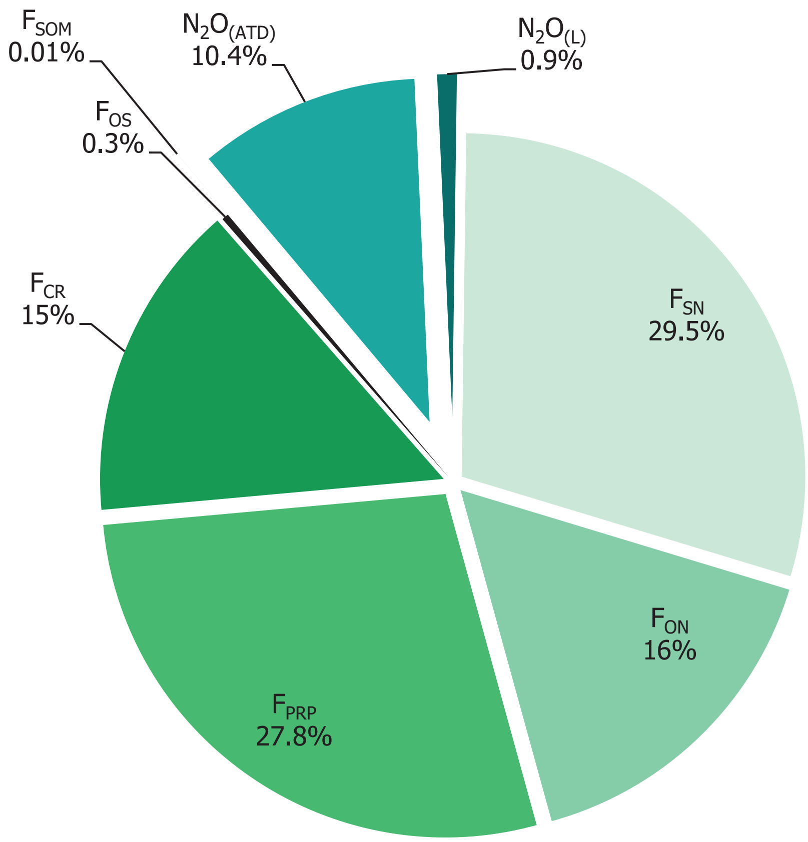


Table 5.21 Overview of N_2O emissions from managed soils, 1990–2022

Year	Agriculture Total	Agricultural soils					
		Total		Direct N_2O		Indirect N_2O	
	(kt CO_2 eq.)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)
1990	51 848	15 391	29.7	13 490	26.0	1 901	3.7
1995	49 030	14 110	28.8	12 403	25.3	1 708	3.5
2000	46 033	15 001	32.6	13 270	28.8	1 730	3.8
2005	46 266	15 023	32.5	13 348	28.9	1 675	3.6
2010	47 678	15 195	31.9	13 547	28.4	1 648	3.5
2011	50 268	15 571	31.0	13 867	27.6	1 704	3.4
2012	56 258	17 241	30.6	15 328	27.2	1 912	3.4
2013	59 360	18 641	31.4	16 582	27.9	2 059	3.5
2014	59 498	18 512	31.1	16 431	27.6	2 081	3.5
2015	59 208	18 728	31.6	16 638	28.1	2 090	3.5
2016	61 690	20 635	33.4	18 357	29.8	2 277	3.7
2017	66 329	21 043	31.7	18 703	28.2	2 340	3.5
2018	68 910	20 523	29.8	18 212	26.4	2 311	3.4
2019	71 517	21 698	30.3	19 253	26.9	2 445	3.4
2020	76 437	24 417	31.9	21 666	28.3	2 750	3.6
2021	75 376	23 396	31.0	20 707	27.5	2 689	3.6
2022	71 512	22 318	31.2	19 790	27.7	2 527	3.5

Figures in the table may not add up to the totals due to rounding.

Table 5.22 Categories of Direct N_2O emissions of agricultural soils, 1990–2022

(kt CO_2 eq.)

Year	Total N_2O Emissions from Managed Soils	Direct N_2O Emissions from Managed Soils						
		Total	Inorganic N Fertilizers (F_{SN})	Organic N Fertilizers (F_{ON})	Urine and Dung Deposited by Grazing Animals (F_{PRP})	Crop Residues (F_{CR})	Loss/ Gain of soil organic matter (F_{SOM})	Culti-vation of Organic Soils (F_{OS})
1990	15 391	13 490	4 996	2 466	4 551	1 405	NO	73
1995	14 110	12 403	4 388	2 320	4 171	1 450	0.1	73
2000	15 001	13 270	5 741	2 163	3 720	1 573	0.2	73
2005	15 023	13 348	5 715	2 099	3 552	1 910	0.5	73
2010	15 195	13 547	5 596	2 091	3 558	2 230	0.9	73
2011	15 571	13 867	5 244	2 272	3 897	2 380	1.0	73
2012	17 241	15 328	5 963	2 540	4 371	2 380	1.1	73
2013	18 641	16 582	6 597	2 675	4 632	2 605	1.1	73
2014	18 512	16 431	6 217	2 782	4 860	2 499	1.1	73
2015	18 728	16 638	6 190	2 801	4 889	2 683	1.1	73
2016	20 635	18 357	7 897	2 806	4 885	2 695	1.2	73
2017	21 043	18 703	7 348	3 080	5 329	2 872	1.3	73
2018	20 523	18 212	6 361	3 261	5 626	2 890	1.4	73
2019	21 698	19 253	7 007	3 379	5 842	2 951	1.4	73
2020	24 417	21 666	8 548	3 626	6 279	3 139	1.5	73
2021	23 396	20 707	7 443	3 733	6 475	2 981	1.5	73
2022	22 318	19 790	6 577	3 580	6 213	3 346	1.6	73

F_{SOM} refers to mineralization/immobilization associated with loss/gain of soil organic matter and related activity data are given in Annex 4. Emissions from this sub-source category originates from the carbon loss due to land use change in perennial cropland to annual cropland while the notation key NO was used for F_{SOM} for the year 1990. Activity data (Area of organic soils) required for the calculation of emissions from F_{OS} are taken from the data available in CRT Table 4.B and CRT Table 4.C. Figures in the table may not add up to the totals due to rounding.

Table 5.23 Subcategories of Organic N fertilizers emissions, 1990–2022

(kt CO_2 eq.)

Year	Total N_2O Emissions from Managed Soils	Total Direct N_2O Emissions from Managed Soils	Organic N Fertilizers (F_{ON})	Organic N Fertilizers (F_{ON})		
				Animal Manure Applied to Soils	Sewage Sludge Applied to Soils	Other Organic Fertilizers Applied to Soils
1990	15 391	13 490	2 466	2 462	2.7	1.2
1995	14 110	12 403	2 320	2 317	2.9	1.0
2000	15 001	13 270	2 163	2 152	10.2	1.5
2005	15 023	13 348	2 099	2 088	10.1	1.2
2010	15 195	13 547	2 091	2 087	2.7	1.0
2011	15 571	13 867	2 272	2 269	2.6	1.0
2012	17 241	15 328	2 540	2 537	2.4	1.1
2013	18 641	16 582	2 675	2 671	2.3	1.0
2014	18 512	16 431	2 782	2 779	2.2	0.7
2015	18 728	16 638	2 801	2 798	2.1	0.8
2016	20 635	18 357	2 806	2 804	2.0	0.8
2017	21 043	18 703	3 080	3 077	2.1	1.1
2018	20 523	18 212	3 261	3 257	2.2	1.5
2019	21 698	19 253	3 379	3 377	1.5	1.1
2020	24 417	21 666	3 626	3 624	0.7	1.5
2021	23 396	20 707	3 733	3 728	2.5	2.3
2022	22 318	19 790	3 580	3 574	4.2	1.3

Other organic fertilizers applied to soils consist only of compost applied to soils. There is no data available and no indication for the use of other organic fertilizers other except compost. Figures in the table may not add up to the totals due to rounding.

Table 5.24 Categories of Indirect N_2O emissions of agricultural soils, 1990–2022

(kt CO_2 eq.)

Year	Total N_2O Emissions from Managed Soils	Indirect N_2O Emissions from Managed Soils		
		Total	Atmospheric Deposition $N_2O_{(ATD)}$	Nitrogen Leaching and Run-off $N_2O_{(L)}$
1990	15 391	1 901	1 758	143
1995	14 110	1 708	1 578	130
2000	15 001	1 730	1 591	139
2005	15 023	1 675	1 535	140
2010	15 195	1 648	1 507	141
2011	15 571	1 704	1 560	144
2012	17 241	1 912	1 753	159
2013	18 641	2 059	1 886	173
2014	18 512	2 081	1 911	171
2015	18 728	2 090	1 917	173
2016	20 635	2 277	2 085	192
2017	21 043	2 340	2 146	194
2018	20 523	2 311	2 123	188
2019	21 698	2 445	2 246	199
2020	24 417	2 750	2 525	225
2021	23 396	2 689	2 474	215
2022	22 318	2 527	2 322	205

Figures in the table may not add up to the totals due to rounding.

Direct N_2O emissions from agricultural soils are a result of addition of nitrogen in the form of inorganic nitrogen fertilizers, organic nitrogen fertilizers (predominantly in the form of animal manure), inputs from above-ground and below-ground crop residues and from forages during pasture renewal, mineralization of cropland soil organic matter loss, urine and dung deposited by grazing animals, and cultivation of organic soils. These combined direct N_2O soil emissions contributed 19 790 kt CO_2 eq. (88.7%) to emissions from the agricultural soils category and around 28% of emissions under the total Agriculture sector in 2022. This is an increase of 6 300 kt CO_2 eq. (46.7%) from the 1990 reported figure of 13 490 kt CO_2 eq.

A major direct source of N_2O emissions from agricultural soils is an outcome of the application of synthetic fertilizers. Around a fourth (25.1%) of increase in direct emissions from agricultural soils, observed between 1990 and 2022, is a result of an increase in synthetic fertilizers application. Widespread increase in the use of such nitrogen-based fertilizers has been driven by the need for greater crop yields and more intensive farming practices. In 2022, N_2O emissions from synthetic nitrogen fertilizers contributed 6 577 kt CO_2 eq. (29.5%) to emissions from the managed soils category. This is an increase of 1 581 kt CO_2 eq. (32%) from the 1990 level of 4 996 kt CO_2 eq. Nitrogen emissions of synthetic fertilizer contributed 9.2% to the total emissions under the agriculture sector for the latest reported year.

In 2022, N_2O emissions from organic N fertilizers contributed 3 580t CO_2 eq. (16%) to emissions from the agricultural soils category and 5% of emissions under the total agriculture sector. Activity data (as dry matter) for sewage sludge and compost are both gathered within TurkStat. The country-specific nitrogen content value for sewage sludge is taken as 5.15% calculated as an average according to the values presented in a specific research study (Topaç and Başkaya, 2008), while the nitrogen content for compost is taken as 1%. The only source of emissions due to other organic fertilizers is compost because there are neither activity data available on possibly other organic fertilizers except for compost data nor an indication of such an activity.

An increase of 1 113 kt CO_2 eq. (45.2%) is observed from the 1990 level of 2 466 kt CO_2 eq. of N_2O emissions due to organic nitrogen fertilisers of which sewage sludge applied to soils marks a slightly peculiar trend observable on Table 5.23. Since Türkiye applied the Tier 1 methodology, emissions are directly linked to activity data changes. In the initial years, the number of municipal wastewater treatment plants increased in our country leading to an increase in emissions thereof. Thereafter, three factors could be given which resulted in a reduction of these emissions: First, increase in number of landfilling sites affected the trend in sewage sludge applied to soils. Second, new legislations which set criteria on sewage sludge for its use on agricultural soils limited the use of sewage sludge on soils. Third, some wastewater treatment plants using sewage sludge extensively before, changing their treatment methods.

As observed from Table 5.22, N_2O emissions from urine and dung deposited by grazing animals contributed 6 213 kt CO_2 eq. (27.8%) to emissions from the agricultural soils category and 8.7% of emissions under the total agriculture sector in 2022. This is an increase of 1 662 kt CO_2 eq. (36.5%) from the 1990 level of 4 551 kt CO_2 eq. Moreover, N_2O emissions from crop residues contributed 3 346 kt CO_2 eq. (15%) to emissions from the agricultural soils category and 4.7% of emissions under the total agriculture sector. This is a value of more than twofold presenting an increase of 1 942 kt CO_2 eq. (138.3%) from the 1990 level of 1 405 kt CO_2 eq.

Emission calculations from cultivation of organic soils are directly based on related LULUCF sector data entered into CRT Tables 4.B and 4.C while the related activity data source is the new LULUCF reporting system (LRS) in Türkiye for which further information is presented in the LULUCF sector overview section.

Indirect N_2O emissions were calculated as 2 527 kt CO_2 eq. for 2022. Indirect N_2O emissions through atmospheric deposition amounted to 2 322 kt CO_2 eq. (10.4%) from the agricultural soils category and 3.2% of emissions under the entire agriculture sector for 2022. This is an increase of 564 kt CO_2 eq. (32.1%) from the 1990 level of 1 758 kt CO_2 eq. Indirect N_2O emissions through leaching and runoff added 205 kt CO_2 eq. (0.9%) to emissions from the agricultural soils category in 2022 and 0.3% of emissions under the total agriculture sector.

Briefly, agricultural soils emissions have increased by around 45% (approximately 6.9 Mt CO_2 eq.) between 1990 and 2022. The increase is a result of the emission changes of direct and indirect N_2O emissions from managed soils. The former, direct N_2O emissions increased by around 6.3 Mt CO_2 eq. and the latter, indirect N_2O emissions, by 0.6 Mt CO_2 eq. for the given period, 1990-2022. The total net increase of 6.3 Mt CO_2 eq. of direct N_2O emissions is a result of changes in inorganic N fertilizers, organic N fertilizers, urine and dung deposited by grazing animals, crop residues subcategories, and loss of soil organic matter. The related figures of changes for 1990-2022 concerning these five subcategories mentioned are 1 581 kt (31.7%), 1 113 kt (45.2%), 1 662 kt (36.5%), 1 942 kt (138.3%), and 1.5 kt CO_2 eq. respectively. Estimations from cultivation of organic soils are constant at 73 kt. Organic N fertilizers are further subdivided into three groups, namely animal manure, sewage sludge, and other organic fertilizers (which consists entirely of compost), all applied to soils. The increase in animal manure applied to soils is 1 112 kt (45.2%) from 2 462 kt to 3 574 kt whereas the two other organic N fertilizer subcategories increased as presented in Table 5.23. On the other hand, the total increase of 0.6 Mt CO_2 eq. of indirect N_2O emissions is divided into two categories, atmospheric deposition and nitrogen leaching and run-off. The related figures of changes for these subcategories are 564 kt (32.1%) and 62 kt (43.8%) for the period of 1990-2022, respectively.

Methodological Issues:

N_2O emissions are calculated by using the IPCC T1 approach. The AD used in emission calculations are taken from agricultural statistics of TurkStat. The N_2O EFs are IPCC T1 default factors. Though a key category, for estimating direct N_2O emissions, the use of tier 1 default emission factor value and country-specific activity data are allowed according to the information presented in Box 2 of the decision tree in Figure 11.2 (2006 IPCC Guidelines, Vol.4, Chapter11, page 11.9). Similarly, for estimating indirect N_2O emissions which is also a key category, the use of tier 1 method is also allowed according to the information presented in Box 3 of the decision tree in Figure 11.3 (2006 IPCC Guidelines, Vol.4, Chapter 11, page 11.20).

When a crop is harvested, a portion of the crop is left in the field to decompose. The remaining plant matter is a nitrogen source that undergoes nitrification and denitrification and can thus contribute to N_2O production. Crop residue emission calculations follow the principles shown in the 2006 IPCC Guidelines. N_2O emissions are now calculated according to all cultivated plants in Türkiye. Both aboveground and belowground crop residues are included. Crop yields vary from year to year, as well as cultivated areas, which cause fluctuations in crop residue emissions. It should be further added that the default EF used for crop residues is 0.01 (kg N_2O–N)/(kg N) except for the EF used for flooded rice which is 0.003 (kg N_2O–N)/(kg N). This difference in EFs used in calculations for crop residues emissions is the reason which leads to inconstant implied emission factors over the reporting period. The following table summarizes the crop headings for which N_2O emissions due to crop residues are calculated in our country.

Table 5.25 Crop data used for crop residue calculations

Major Crop Types	Individual Crops	
Grains	Maize	Sorghum
Beans & Pulses	Wheat	Soybean
Tubers	Rice	Dry bean
Root crops, other	Barley	Potato
N-fixing forages	Oats	Peanut
Non-N-fixing forages	Millet	Alfalfa
Grass-clover mixtures	Rye	

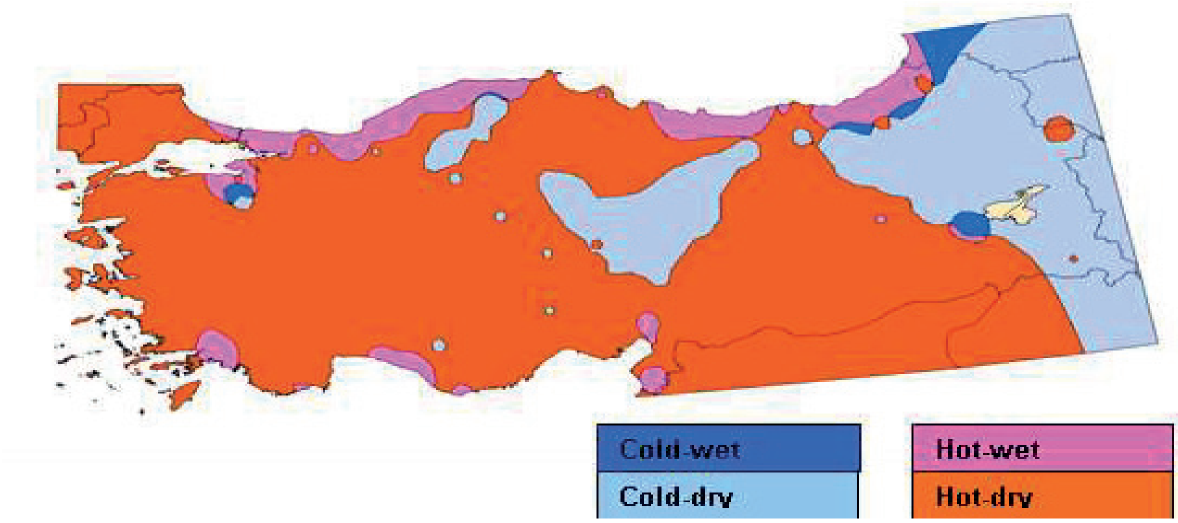
Source category	Gas	Comments on time series consistency
3.D.1	N_2O	All EFs are constant over the entire time series for F_{SN}, F_{OS} and all sub-categories of F_{ON} . The same EF for F_{CR} is used except for flooded rice and the EF for F_{PRP} is chosen according to livestock species.

In the 2016 Assessment Review Report of Türkiye, published on 24 April 2017, a recommendation was made by the Expert Review Team to investigate the actual leaching conditions in Türkiye and estimate the most likely $Frac_{LEACH-(H)}$ for its national conditions and include justification of the $Frac_{LEACH-(H)}$ value used in its NIR. The ERT also noted that taking into account the dry conditions in Türkiye and the use of a $Frac_{LEACH-(H)}$ of 0.3, a likely overestimation is taking place. To address this recommendation and use a more precise $Frac_{LEACH-(H)}$ value this issue was evaluated. As a result, a revised country-specific $Frac_{LEACH-(H)}$ value of 0.015 is calculated and used with respect to the footnote of Table 11.3 shown in the 2006 IPCC Guidelines Volume 4. While calculating this parameter, following steps are implemented: First, the Climate Map (Figure 5.11) was used as a reference data source while keeping in mind that in this data source, the entire 12 months in a year (including also the dry months of June, July and August) are taken into account, not 9 months as mentioned in the footnote of Table 11.3 shown in the 2006 IPCC Guidelines Vol.4. Secondly, soil water-holding capacity is assumed to be zero as a conservative approach. In other words, if rainfall exceeds the potential evapotranspiration then it is assumed that surface runoff or leaching occurs. In general conditions, there is a soil layer (shallow or deep) that hold water and disable surface runoff but it is not possible to make an assessment on the water capacity of soils for the whole country. Thirdly, it is assumed that leaching/run-off occurs in all wet areas shown in the Climate Map but deos not occur in the dry areas of the country. Thus, a ratio between wet and dry areas has been determined and multiplied by 0.3 to result in 0.015 as a $Frac_{LEACH-(H)}$ value[7]. This newly calculated value has been used since the submission of the 1990-2016 GHG Inventory.

According to the 2006 IPCC Guidelines, a climate map of Türkiye (Figure 5.11) was prepared before and this map was used to estimate a country-specific $Frac_{LEACH-(H)}$ value. Four sub-climate types have been identified based on the 2006 IPCC Guidelines that use basic climatic parameters of temperature, potential evapotranspiration and precipitation. The Climate map given below is taken from the IPCC Climate Zones which is also presented as Figure 3A.5.1 on page 3.38 of the 2006 IPCC Guidelines Volume 4.

[7] Please refer to the section related to the agriculture sector of Annex 4 in this NID for calculation details.

Figure 5.11 Climate Map of Türkiye



Regarding emission calculations from crop residues, TurkStat received country-specific data on renewal fractions and fractions removed from the MoAF. Renewal fraction for a yearly crop is 1 by definition of 1/X (where X is 1 year). This figure is used for most of the crops presented in the classification of Table 11.2 on pages 11.17-11.18 of the 2006 IPCC Guidelines Vol. 4 (since almost all crops are yearly crops). A fraction of 0.25 (as a result of 1/X where X is 4 years) was used only for the following major crop types and individual crops according to the information received from the Ministry of Agriculture and Forestry: perennial grasses, grass-clover mixtures, alfalfa.

Fraction removed values are given for all major crop types and individual crops as received from the Ministry of Agriculture and Forestry as follows: first for major crop types: grains (0.75), beans & pulses (0.80), tubers (0.00), root crops and other (0.00), N-fixing forages (0.80), non-N-fixing forages (1.00), perennial grasses (0.90), grass-clover mixtures (0.90); and second for Individual crop types: alfalfa (0.90), maize, millet, soya bean and dry bean (0.80), wheat, rice, barley, oats, sorghum and rye (0.75), peanuts (0.70); potato (0.00). The use of these data set helped in order to reflect the country-specific conditions in an improved way. It should be further noted that default factor values shown in Table 11.2 of the 2006 IPCC Guidelines Vol.4 were used to calculate emissions from crop residues according to the T1 method. Default factors used for F_{CR} calculations include dry matter fraction of harvested product, N-content of above-ground residues, ratio of below-ground residues to above-ground biomass, and N content of below-ground residues. Additionally, default slope and intercept figures regarding above-ground residue dry matter from the same table are also used in the calculations.

Uncertainties and Time-Series Consistency:

The AD for this sector are gathered from agricultural statistics of TurkStat except for data on synthetic fertilizer consumption amounts, which is obtained from the MoAF. By using Equation 3.1 and 3.2 in the 2006 IPCC Guidelines Vol. 1, uncertainties for the AD are calculated as 20.24% by TurkStat for N_2O Emissions from Managed Soils. In a similar manner, the respective EF uncertainty for this category is figured out as 93.02% after taking the default uncertainties in the 2006 IPCC Guidelines into consideration.

Source-Specific QA/QC and Verification:

The 2006 IPCC Guidelines are used for the QA/QC procedures of the National GHG emissions inventory. A National Inventory System QA/QC Plan prepared by TurkStat is also a significant tool for implementing QA/QC principles for the Inventory. AD for this source category are gathered mainly from the Agricultural Statistics Department of TurkStat. Data used for calculations are published also as official statistics by TurkStat which have their own QA/QC procedures. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined.

It should be further noted that the activity data for synthetic fertilizer are also almost entirely consistent with the data available on International Fertilizer Association's (IFA) website.

Recalculation:

Minor revisions are mainly a result of the newly added emissions related to the source category on soil organic matter and updated parameters affecting calculations of crop residues emissions. For this source category, the recalculation has an average increasing effect of 0.12% for the period 1990-2021 with a revision percentage of 0.23% for 2021.

Planned Improvement:

All data and methodologies are kept under review. Overall, a tier 2 method cannot be applied currently due to insufficient country-specific data, though a few country-specific data are used, as appropriate, in emission calculations from this source category.

5.6. Prescribed Burning of Savannas (Category 3.E)

This source category of agriculture emissions is not relevant to Türkiye.

5.7. Field Burning of Agricultural Residues (Category 3.F)

Source Category Description:

The burning of residual crop material releases CH_4, N_2O, CO, NO_x and NMVOC gases of which CO, NO_x and NMVOC are gases leading to indirect GHG gas emissions. The resulting atmospheric release of agricultural residues is not considered to be a net carbon dioxide source, as carbon is being absorbed again during the growing season. This source category is not a key category. Emission values due to field burning of crop residues are presented in Table 5.3 for all thirty-three reporting years. After consultations with the Ministry of Forestry and Agriculture (MoAF) and our own research, wheat, barley, maize and rice cultivation areas in Türkiye were found to be included in field burning. As field burning is illegal and widely under control, it is becoming rare. Also, the machinery is usually able to manage the excess straw left on fields after harvesting. As presented in detail in Table 5.26, CH_4 and N_2O emissions amounted to 147 kt CO_2 eq. and 36 kt CO_2 eq., respectively, for this source category in 2022.

Table 5.26 Emissions from field burning of agricultural residues, 1990 and 2022

	Emissions (kt CO_2 eq.)				Changes from 1990 to 2022		Percentages of the agricultural sector (%)	
Category	1990	(%)	2022	(%)	(kt CO_2 eq.)	(%)	1990	2022
Field burning of agricultural residues	370	100	182	100	-187	-50.7	0.71	0.26
CH_4	297	80	147	80	-150	-50.7	0.57	0.21
N_2O	73	20	36	20	-37	-50.7	0.14	0.05

Figures in the table may not add up to the totals due to rounding.

In 2022, field burning of agricultural residues contributed 183 kt CO_2 eq. This emission value represented 0.26% of all agricultural emissions. Total field burning CO_2 eq. emissions presented a decreasing trend because of prohibitive legislative measures undertaken. CH_4 and N_2O emissions from field burning have mostly a negative trend except for some years. Prohibiting measures and increase of public awareness related to field burning are key in this decreasing trend and relevant authorities impose also fines on misconduct. Additionally, the use of advanced agricultural machinery assisting farmers in handling crop residues more easily, could also be considered as another factor leading to the reduction of field burning practices. The respective percentage change from this source category is -64.2% from 1990 to 2022.

Methodological Issues:

Activity data used in the emission estimation are taken from TurkStat agricultural statistics. The emissions are calculated according to the 2006 IPCC Guidelines, Volume 4, Equation 2.27 presented in Chapter 2. Crop residue per hectare is multiplied with area of both cereal and then with fraction burned, combustion factor and the related emission factor. Both CO_2 and N_2O emissions are calculated using the IPCC Tier 1 approach. The values calculated for CH_4 and N_2O emissions were converted to their CO_2 equivalents by multiplying the values with their respective global warming potential factors. Other emission values under this source category, NO_x, CO, and NMVOC, are not estimated. Most of the farmers obey the rules, prohibiting stubble burning leaving some farmers still practising crop residue burning.

Uncertainties and Time-Series Consistency:

The AD for this sector were gathered from agricultural statistics of TurkStat. Uncertainty values concerning AD for two GHG sources under this source category, namely CH_4 and N_2O, are each estimated to be 50% whereas EF uncertainty values of both gases are estimated to be 40% as recommended in the 2006 IPCC Guidelines.

Source category	Gas	Comments on time series consistency
3.F	CH_4, N_2O	All EFs are constant over the entire time series

Source-Specific QA/QC and Verification:

The 2006 IPCC Guidelines are used for the QA/QC procedures of National GHG emission inventory in order to attain quality objectives. A National Inventory System QA/QC Plan prepared by TurkStat is also a significant tool for implementing QA/QC principles for the Inventory. AD for this source category are gathered mainly from the Agricultural Statistics Department of TurkStat. Data used for calculations are also published as official statistics by TurkStat which have their own QA/QC procedures. Calculations are implemented every year during preparation phase of the NIR. If errors or inconsistencies are found, they are documented and corrected accordingly. Regarding field burning of agricultural residues, a more representative data for burned fractions were received from MoAF. Annual checks are undertaken whether new scientific articles for updating emission factors have been published in Türkiye.

Recalculation:

Minor revisions are a result of an updated fraction in the calculations. For CH_4 and N_2O emissions of this source category, the recalculation has an average increasing effect of 0.015% for the period 1990-2021, while the increasing effect is 0.036% for 2021.

Planned Improvement:

All data and methodologies are kept under review and there are no further planned improvements regarding this source.

5.8. Liming (Category 3.G)

Possible data sources are considered for this mandatory category. Three factors are possibly more important than others which explain the use of carbonate limestone applied to soils in our country. First, soils with lower pH values are present mainly in the Black Sea Region and Marmara Region. Second, it is not an inexpensive method to reduce acidity of soils for agricultural producers by using carbonate limestone. Third, there are also non-carbon containing materials available, which are suitable to be applied on soils in order to reduce acidity. Our research is almost decisive in estimating CO_2 emissions amounted to far less than 100 kt for 2015 due to liming applied on soils. Additionally, TurkStat received the information from Lime Producers Association (KISAD) that the latest (and the highest) figure for limestone used in the agriculture sector was estimated at 200 000 t per year for the period, 2010-2014. The given amount indicates to a likely emission level of 88 kt CO_2 emissions from this source category for each given year of the period. Therefore this category is considered as insignificant according to Decision 18/CMA.1, Annex, paragraph 32, and reported as not estimated in the CRT.

5.9. Urea Application (Category 3.H)

Source Category Description:

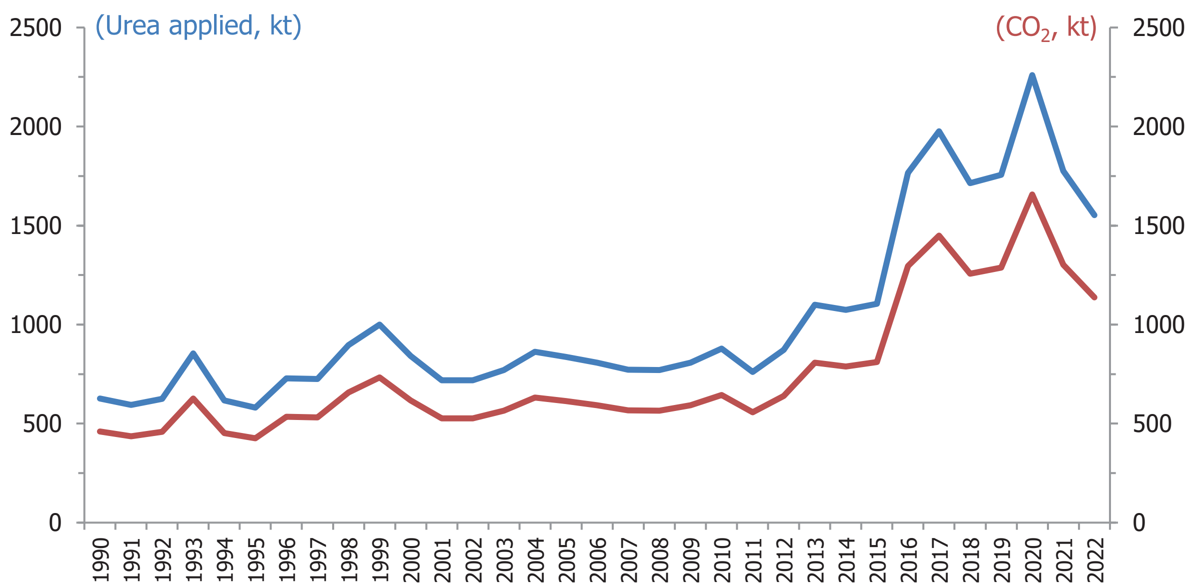
Adding urea to soils during fertilisation leads to a loss of CO_2 that was fixed in the industrial production process (IPCC, Vol.4, 2006). Urea ($CO(NH_2)_2$) is converted into ammonium (NH_4^+), hydroxyl ion (OH^-) and bicarbonate (HCO_3^-), in the presence of water and urease enzymes. Similar to the soil reaction following addition of lime, bicarbonate that is formed evolves into CO_2 and water (IPCC, Vol.4, 2006).

CO_2 emissions from applied urea led to emissions as high as 1 138 kt CO_2 in 2022 which is an amount representing 1.6% of agricultural emissions. Emissions from the urea application in 2022 were 678 kt CO_2 (147.4%) above its 1990 level of 460 kt CO_2. This source category, CO_2 emissions from urea application, is not a key category.

Observed recent increases (except in 2018, 2021, and 2022) in the use of urea application is a result of its use as a substitute for nitrogen-based fertilizers. Türkiye has limited the use of nitrogen-based fertilizers since June 2016 leading to a shift in farmers’ preferences.

Emissions values due to urea application are shown in Table 5.3 for the period of 1990-2022 in the sector overview section. Figure 5.12 presents the annual amount of urea application in kt (line drawn in blue - left axis) and CO_2 emissions emitted in kt (line drawn in dark red - right axis). A direct relationship between the two values is observed in the figure. In addition, an overall sharp increasing trend can be seen in the last ten years except for the years 2018, 2021, and 2022 which reflect decreases. Changes in estimations are directly linked to changes in activity data for the consumption of urea.

Figure 5.12 Urea application and emitted CO_2, 1990–2022



Methodological Issues:

Emissions associated with the application of urea are calculated by using T1 approach (equation 11.13; IPCC, 2006), using the default EF for carbon conversion of 0.20. This value equals the carbon content of the atomic weight of urea. In order to calculate CO_2-C emissions resulting from urea application, the annual total amount of urea applied to the soils in the country is determined. Related AD, required for the calculation are taken from the website of MoAF under the title of "Chemical fertilizer production, consumption, import and export statistics" which is updated every year for the subsequent year. The data time series starts from the year 1981 and our country uses directly the consumption data presented as the related activity data which is accessible on the following link: https://www.tarimorman.gov.tr/Konular/Bitkisel-Uretim/Bitki-Besleme-ve-Tarimsal-Teknolojiler/Bitki-Besleme-Istatistikleri#

Uncertainties and Time-Series Consistency:

Under the IPCC (2006) T1 methodologies, the default EFs are used, which assume conservatively that all carbon in the urea is emitted as CO_2 into the atmosphere. The default EF is assumed to be certain under this theoretical assumption. A default 10% uncertainty is applied regarding the AD used in the emission calculation of urea application, whereas the uncertainty of the EF is taken as 50% as presented in the IPCC Guidelines under the related section.

Source-Specific QA/QC and Verification:

The 2006 IPCC Guidelines are used for the QA/QC procedures of the National GHG emission inventory. A National Inventory System QA/QC Plan, prepared by TurkStat, is a significant tool for implementing QA/QC principles for the Inventory. AD for this source category are obtained from the MoAF. Data used for calculations are a part of official statistics, which have their own QA/QC procedures. Specially, the time series was checked for consistency. As a general QC check, the multiplications of activity data and emission factors were double-checked for CO_2 emissions from urea application. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined. It should be further noted that the activity data for urea applied are almost entirely consistent with the data available on the website of the International Fertilizer Industry Association (IFA).

Recalculation:

There was no recalculation exercised regarding emission estimates from this source category in this submission.

Planned Improvement:

All data and methodologies are kept under review. There are no further planned improvements in this source category.

5.10. Other Carbon-Containing Fertilizers (Category 3.I)

This source category of agriculture emissions is not relevant to Türkiye.

5.11. Other (Category 3.J)

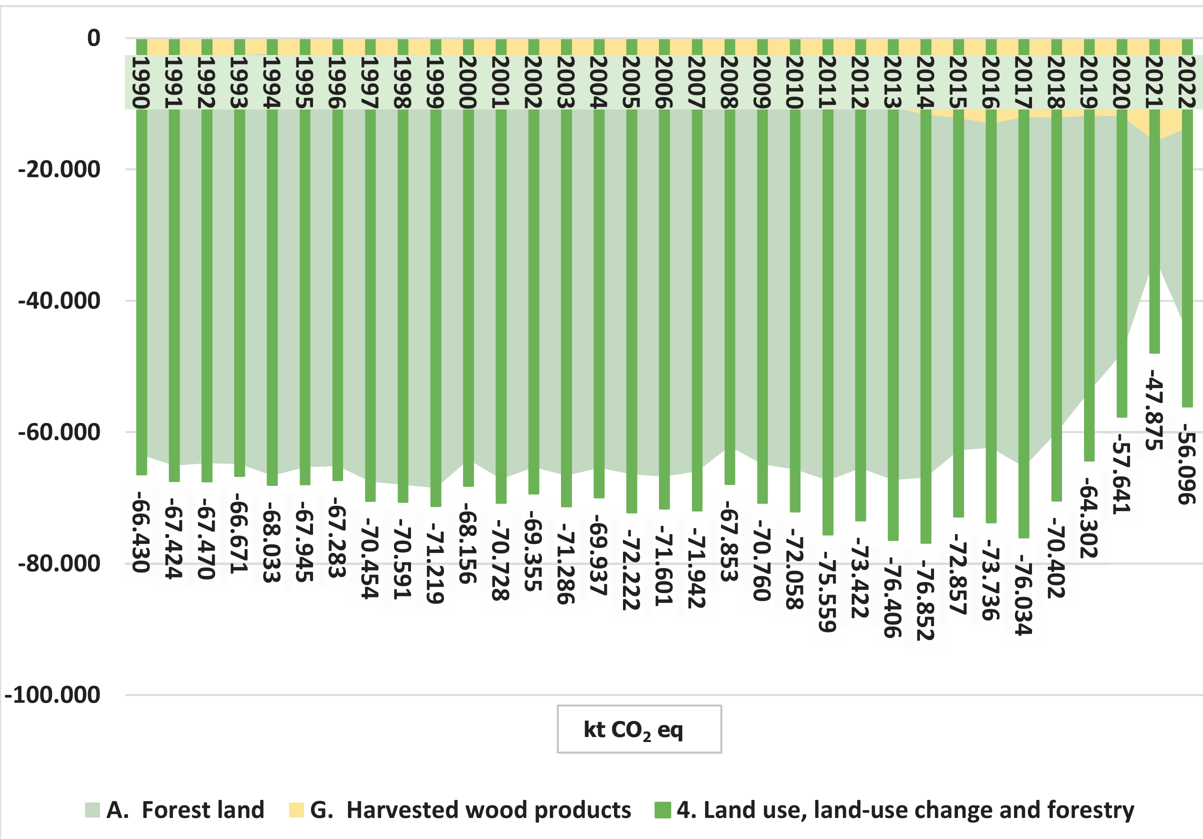
There are no other activities to be considered under this sector.

6. LULUCF (CRT Sector 4)

6.1. Sector Overview

The LULUCF sector of Türkiye is a net removal dominated by forests. The 23 Mha of forest area removed a net 44,75 Mt of CO_2 eq. from the atmosphere in 2022. Other land uses are net emissions while accounting equals to 5 percent of forest land removals. The total removals of the sector when HWP was added has been 58,4 Mt of CO_2 eq..Total net LULUCF removals has been 56,1 Mt of CO_2 eq. due to 2,3 Mt of CO_2 eq. emission from other land uses. The reason for the decrease in the trend for the last 4 years comparing 2018 was intense wood harvest policies due to salvage logging and to meet of demand of the growing wood industry of Türkiye and mega forest fires and other natural disturbances triggered by climate change. These natural disturbances also caused decreasing in annual increment values per hectare.

Figure 6.1 The trend of LULUCF sector net removals including key sectors (Forest Land and HWP) 1990-2022



The LULUCF sector methodologies related to activity data have entirely been modified with the support of EU funded project entitled "Technical Assistance for Developed Analytical Basis for Land Use, Land Use Change and Forestry (LULUCF) Sector" started in August 2017. The project was completed in July 2019 but so far provided significant improvements on;

i. Developing spatially explicit land use matrices for the land uses and conversions starting from 1990,
ii. Capacity building in relevant inventory agencies,
iii. Development of a Program of Works, Annual Work Plan and Compendium,
iv. A new system to calculate and report GHG emissions/removals in LULUCF sector,
v. Activity data disaggregated into 8 Ecoregions and 28 Forest Administrative regions for higher level accuracy,
vi. Updated NIR.

The new LULUCF reporting system (LRS) of Türkiye is composed of below elements:

- A spatially explicit land cover-driven AD produced by an experienced international company. The system uses tracks all land cover with satellite images since 1990 and detects all changes on an annual basis. Each 1 hectare unit of land (1 ha) is tracked for the reporting period and calculated for emissions and removals on a consistent approach
- Updated land use definitions
- A new system of reporting that is capable of performing calculations; harmonizing spatial data with EF data, archiving, and tools to enhance QA/QC
- Re-assessed EFs by a team of experts
- An EF database and Reference Library were developed and used. The system enables experts to update the EFs and coefficients on a continuous basis
- A database has been developed to query all land covers and changes. Thus, land cover database on Satellite images can be checked and verified anytime

The LRS is managed and used by a group of national experts for different elements. This means that the inventory is prepared by more than 10 experts each focusing on a different item. This enables sharing of responsibility and improvement potential.

The new system increased the transparency significantly by using AD produced by an international remote sensing company, and a renewed NIR. Furthermore, the new spatially explicit land use tracking system improved completeness, accuracy and consistency because the same methodology has been used for the whole reporting period and for all land uses with around 90 percent accuracy. The new reporting system caused significant changes in emissions and removals. The main categories of removals have been FL-FL and HWPs. The outcome of the key category analysis for 2022 was listed in Table 6.1.

Table 6.1 Key categories identification in the LULUCF sector (Tier 1)

	CATEGORIES OF EMISSIONS AND REMOVALS	Gas	2022
4.A.1	Forest Land Remaining Forest Land	CO_2	Key (L,T)
4.G	Harvested Wood Products	CO_2	Key (L,T)

Within the new reporting system, a national EF database together with a reference library has been established. They are very similar to the IPCC EF database in structure and include all data used in the inventory even the default coefficients.

The context and management of the EF database are as follows;

Emission factors are the second set of data, needed for estimation of GHG emissions and removals. An emission factor (EF) is defined as the average emission rate of a given GHG for a given source, relative to units of activity (IPCC 1996). Emission factors can be collected from various sources, from national and international statistics and monitoring, databases, research studies, scientific papers, technical reports etc. The use of appropriate emission factor is essential as wrong selection may lead to under- or overestimation of emissions and removals. In general, the IPCC guidelines include a large list of emission factors, which can be used when Tier 1 methods are selected for estimation. Moreover, there exists an emission factor database (EFDB: https://www.ipcc-nggip.iges.or.jp/EFDB/main.php) of the IPCC, which also includes a large set of emission factors, relevant to the LULUCF.

The following approach is implemented for updating the national EF database:

- Check for improvement of EF database on annual basis (e.g. new EF gathered, higher Tier method selected, category become key category etc.).
- Collect country-specific emission and stock change factors for all key categories.
- Collect all relevant default emission factors of the IPCC for other categories (non-key).
- Assign appropriate specific emission and stock change factors to each corresponding category.
- Add and update EF database when new or improved emission factors are obtained or determined, respectively.
- Store a reference of the EF in the archive (data source, uncertainty, background data etc.).
- Record the person and reason whenever your update the EF database.

The EF database is embedded in the reporting system on the main computer and has the below table format;

EF ID	GAS	DESCRIPTIOI	PRACTICES	CONDITIONS	REGION	VALUE	STD DEV	RANGE	on Coeff (%)	UNIT	REFERENCE
Soil											
1	CO2	Soil C Stock	native broadleaved forest	grazed forests and shrubs, not	Southeast Anatolia Dec	44.33	12.23	33.64-64.00	27.58	T/ha	BUDAK, M., GÜNAL, H., 2018. Yukarı Dicle
2	CO2	soil organic ca	Mature and young fir stands and adjacent pasture and agriculture sites	The study area consists of a variation of broadleaf and conifer stands with ages between 40 and 150 year homogenous soils	Mature and Young Fir Stands- Pasture and Agriculture Sites in Kastamonu Northwest Region	Forest (mature fir) 47.4 Forest (young fir) 48.6	Forest (mature fir) ±13.4 SOC Forest (young fir) ±13.9 SOC		the descriptive statistics table is not available	T/ha	Temel SARIYILDIZ (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey) , Gamze SAVACI (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey) , Züleyha MARAL (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey)
3	N	total nitrogen	Mature and young fir stands and adjacent pasture and agriculture sites	The study area consists of a variation of broadleaf and conifer stands with ages between 40 and 150 year homogenous soils	Mature and Young Fir Stands- Pasture and Agriculture Sites in Kastamonu Northwest Region	Forest (mature fir) 4.45 Forest (young fir) 5.61	Forest (mature fir) ±0.48 STN Forest (young fir) ±0.88 STN		the descriptive statistics table is not available	T/ha	Temel SARIYILDIZ (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey) , Gamze SAVACI (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey) , Züleyha MARAL (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey)

Land-use definitions and the classification systems used and their correspondence to the land use, land-use change and forestry categories

The Land Use definitions of Türkiye have been updated with the new land monitoring system. The country has been divided into 8 ecological zones based on international and national literature. The ecoregions assessment has provided the possibility to disaggregate calculations into more homogenous regions and use more specific EFs and coefficients. The Ecozones identified by Serengil (2018) and their relationship with climate types are given below (Figure 6.2. and Table 6.2.)

Figure 6.2 The ecoregions in Türkiye (Serengil, 2018)

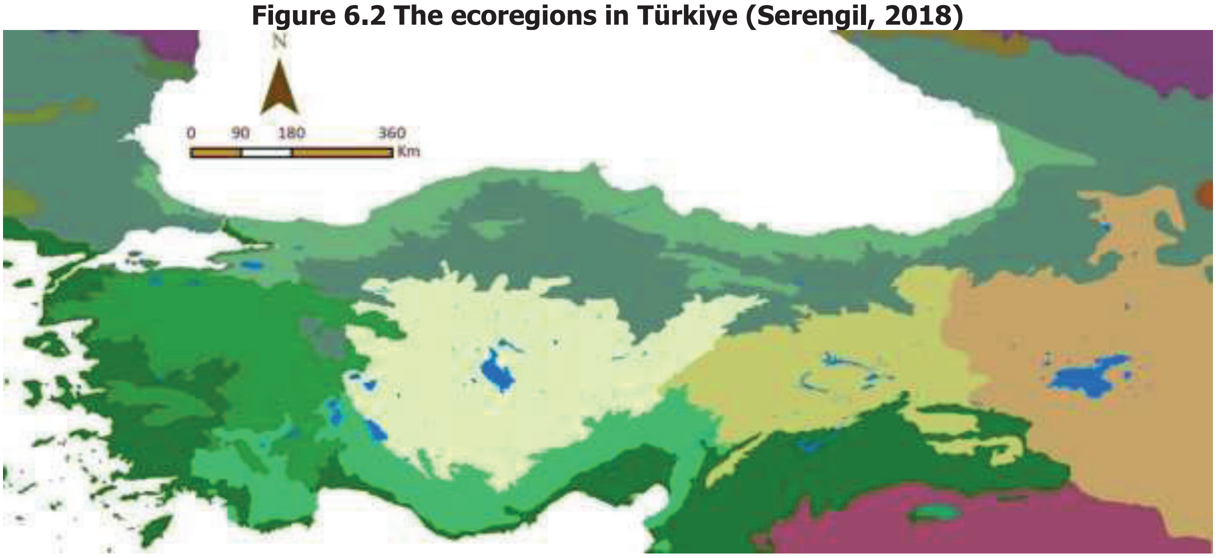


Table 6.2 Ecozones in Türkiye and their relationships with climate classifications (Serengil, 2018)

	Ecozone	Biome	Climate Type	IPCC Climate Type	Map Legend
1	Euxine-Colchic deciduous forest	Temperate deciduous & mixed forest	Black Sea Coastal Zone	Warm Temp Moist	
2	North Anatolian deciduous, coniferous and mixed forest	Temperate deciduous, coniferous and mixed forest	Black Sea Inland Temperate Climate Zone	Warm Temp Dry	
3	Mediterranean coastal zone deciduous and coniferous forest	Mediterranean forest, shrubs	Mediterranean Coastal Zone	Warm Temperate Moist-Dry	
4	Mediterranean Mountain zone	Mediterranean forest, shrubs	Mediterranean Inland Temperate Mountain Climate	Warm Temp Dry	
5	Aegean Inland deciduous and coniferous forest	Mediterranean forest, shrubs	Mediterranean Inland Temperate Climate	Warm Temp Dry	
6	Central Anatolian steppe	Temperate deciduous & mixed forest	Semi Dry Steppe Climate	Warm-Cool Temp Dry	
7	East Anatolian deciduous forest zone	Temperate deciduous & mixed forest	Temperate Continental Climate	Warm Temp Dry	
8	East Anatolian steppe	Temperate grassland, shrubs and steppe	Continental Mountainous Climate	Cool Temp Moist-Dry	

The new definitions of land uses have been explained below. The former forest definition in 2018 submission was the national legal definition. The national definition had a threshold just for the minimum area which is 3 ha. The application of the new definition and spatially explicit land tracking system did not change the forest area drastically but the share of productive forest in forest land category increased. The difference between the old and the new systems has been discussed in Forest land category below.

Forest Land: Forest Land category has been disaggregated into 2 major subcategories;

- Productive Forest: Tree and woodland communities of more than 1 ha with a crown closure of over 10 percent, which are grown by both human efforts and naturally are regarded as Forests.
- Other Wooded Forest (OWF): The same definition applies except for the crown closure. The crown closure for OWF is between 1 to 10 percent. The wooded land with crown closures of less than 1 percent is allocated under grassland.

Cropland: The following land uses are included in the croplands.

- Arable land (Non-irrigated arable land, Permanently irrigated land)
- Permanent crops (Vineyards, Fruit trees and berry plantations, Olive groves)
- Poplar plantations in or near the agricultural area

Grassland: All woody/herbaceous vegetation is defined as grassland. The grasslands include shrubs and trees that provide a crown closure of less than 1 percent. The demand for grazing areas is high in the country and differentiation between managed and unmanaged is not technically possible thus all grasslands are accepted as managed.

Wetlands: This category is divided into two as managed and unmanaged. Only flooded land (dams, irrigation dams and reservoirs) and peatlands are included in the managed wetland definition. Natural systems like rivers and lakes are classified under unmanaged wetlands.

Settlements: Artificial surfaces are reported under Settlements. These include;

- Urban fabric (continuous, discontinuous fabric)
- Industrial, commercial and transport units (Industrial or commercial units, Road and rail networks and associated land, Port areas, Airports)
- Mine, dump and construction sites (Mineral extraction sites, Dump sites, Construction sites,)
- Artificial, non-agricultural vegetated areas (Green spaces like parks and cemeteries that are not classified as forest, sport and leisure facilities)

Other Land: Open spaces with little or no vegetation are defined under Other Land. These include;

- Beaches, dunes, sands
- Bare rocks,
- Sparsely vegetated areas

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

In the previous submission, there was inconsistency between activity data of forestry and other land uses. The AD related to forest land was collected from a tabular database called ENVANIS. The ENVANIS system is the major data source of forest management in Türkiye and provides both area data, increment and other relevant data related to the forests. It bases on 10 years rotation period field measurements that are implemented on 10 percent of the forests in the country. The ENVANIS system provides high accuracy information on stand parameters but has some disadvantages for GHG inventories. These disadvantages are;

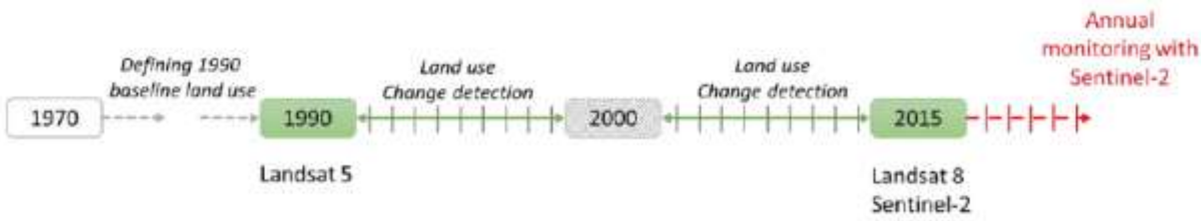
- The forest area in the ENVANIS system uses a national legal forest definition and is not compatible with land cover maps i.e. CORINE. Thus it is not possible to establish a consistent land use matrix with a combination of ENVANIS and spatial databases that base on land cover.
- As 10 percent of the country forests are sampled and measured every year the data given in ENVANIS represents only this amount of updated data.
- The types of conversions are unknown. The forest area increase or decrease is reported but the land use that forest is converted is not. Thus an assumption was made that these area areas are all grassland.

The new system uses data from Forestry Statistics such as annual increment but not the area data. Below are the specifications of the satellite based system that has been produced just to be used for GHG calculations.

The New Satellite Based Land Cover Monitoring System (SBLMS)

A satellite Earth Observation based on AD monitoring system for LULUCF for the entire territory of Türkiye is developed. The system relies on wall-to-wall spatially explicit mappings to analyze LULUCF activity data and changes for the period from 1990 to 2015. The system delivers complete annual land use and land use change matrices, allowing for consistent spatially explicit assessment in high spatial resolution (30m, 1 ha MMU). The matrices report on land use and land use change between the six IPCC Guidelines land use categories and related 11 subcategories. With this system every unit of land is univocally assigned to only one land use category, eliminating double counting or omissions. By providing consistent information on all land use and land use change categories, inconsistencies in previous submissions in land use representation derived from CORINE Land Cover and ENVANIS have been overcome.

Figure 6.3 The temporal structure of the SBLMS with the satellites used



Following similar approaches of other Mediterranean countries, this is achieved through

- detailed mapping of the selected reference years (here 1990, 2000 and 2015) from time series high-resolution satellite images,
- the determination of changes between these reference years and,
- an assessment of the intermediate years through advanced analyses.

Table 6.3 Classification approach for all categories and subcategories under SBLMS

Category	*Classification Approach*
Forest	*The identification of **deciduous** and **coniferous** forests is based on time-series analysis, where phonological changes are used to differentiate between these two classes. Copernicus HRL Forest layers 2015 and 2012 are used as ground truth. Following this differentiation a local filter with a size of 1ha will be applied, where areas without dominant tree type are classified as **mixed** forest.*
Cropland	*Separation of cropland and grassland is a complex task in image classification and requires multitemporal data analyses and reference ground truth data. **Annual** crops have been identified due to their vegetation phenology (periodic change of vegetation status). **Perennial** crops on the other hand are hard to differentiate from forest areas, due to similar spectral characteristics compared to other woody vegetation. Therefore, ancillary information is needed to assist in the identification of perennial croplands (e.g.. LPIS for 2015). The global NASA Crop layer and CORINE are used to prepare samples for both crop sub-categories. A fully automated classification approach for 25 years over entire Türkiye cannot reliably detect different crop types, so statistical information (e.g. TUIK) can instead be used to calculate crop type ratios that are then applied to the detected crop areas, assuming the area estimates in the TUIK database are representative for the entire country.*
Grassland	*Grassland areas are classified by the spectral characteristics detected over time. The differentiation between woody grasslands and herbaceous grasslands is based on spectral classification as well as ruleset to improve accuracy. Woody grasslands, for example, are likely to be found around forests, so their proximity to a forest boundary has been taken into consideration. For consistency woody grasslands that have a crown closure of 1 to 10 percent are merged with Other Forested Areas category.*
Wetland	*Open (artificial) waterbodies are readily detectable with satellite data given their sudden appearance at a fixed point in time (e.g. construction of a dam) and their permanence following that date. Different indices (e.g. Normalized Difference Water Index (NDWI)) are used to efficiently delineate wetlands. Auxiliary data on dam constructions are needed to improve detection accuracy.*
Settlement	*For the identification of settlement areas, indices like the NDVI are used, as they highlight both vegetated and non-vegetated areas. The HRL and CORINE datasets have been used to provide ground truth.*
Other land	*Areas which are covered by bare soil, sand, rocks, and salt marshes will be classified as other land. Permanent snow and ice will also fall under this category, should they be present in Türkiye in any given year.*

Land use baseline establishment

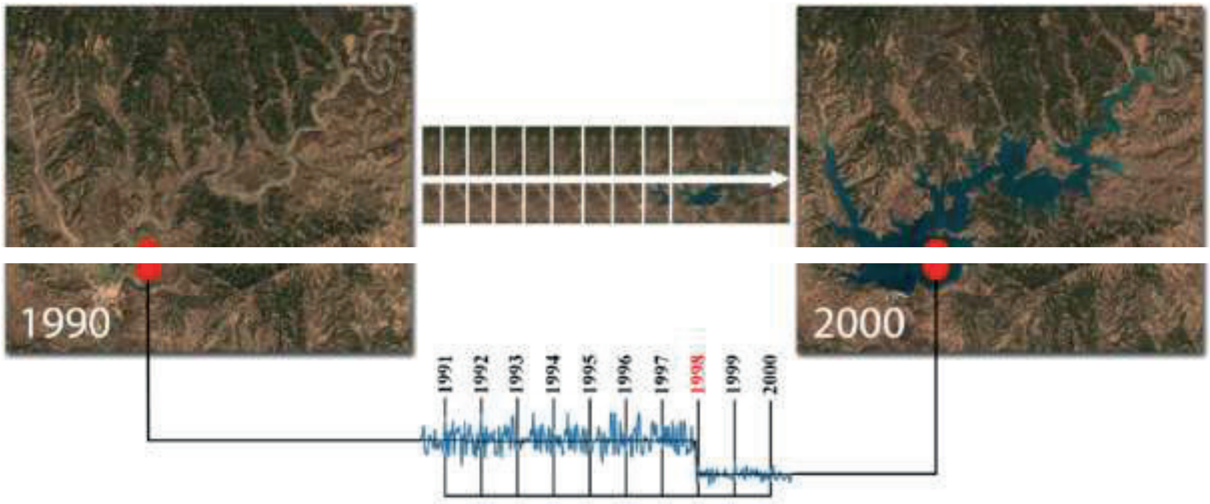
For each of the three reference years (1990, 2000 and 2015) a land cover map has been produced by applying the classification procedures described above. The outputs have further been refined using existing datasets for Türkiye, especially for the differentiation of perennial crops. Due to the different types and amounts of data available for the different time steps, specific methodologies have been applied to achieve consistent outputs over the entire 1990-2015 period.

2015 is the most recent reference year for mapping and AD reporting in this project. With the Copernicus program, the availability of high resolution satellite imagery has dramatically improved and the monitoring system can utilize this wealth of information by including both Sentinel 2 (10-20m) and Landsat 8 (30m) imagery in the production process. In addition to the high availability of satellite imagery, an extensive list of highly accurate, spatially explicit information products have been used to support the mapping in 2015. These include LPIS, Copernicus High Resolution Layers (HRL) for Forest, Wetlands, Grassland, and Settlements, other global data layers (e.g. USGS Global Crop Maps) and other auxiliary data.

Mapping of the intermediate reference year 2000 is primarily based on Landsat 7 with support from Landsat 5 imagery. CORINE is used as auxiliary data.

The reference year 1990 is the base year for UNFCCC reporting and relies primarily on Landsat 5 imagery for mapping. Considering the 20-year-transition rule, it was anticipated that the time from 1970 until 1990 be reviewed for the definition of the 1990 map (see D4.2.1). The Landsat satellite program started in 1972, however, satellite data is only sparsely available for Türkiye until the 1980s and the assessment of approaches chosen by other Mediterranean countries shows that the primary input for 1990 base maps is national forest statistics. The Turkish national forest inventory is available for 1972, however, it is not spatially explicit and uses an incompatible definition for forest which means that it is of very limited use in an assessment of the 1970-1990 period. In order to overcome these high uncertainties, some countries (e.g. Greece) have chosen to report 1990 as is and commence with any land use changes from then on. In our approach, we used the 1990 land cover/land use map on Landsat 5 imagery as the base year.
The monitoring system uses an accurate approach by performing change detection for intermediate years through breakpoint analyses of spectral indices calculated from all satellite data available for the intermediate period. This method provides accurate estimates of changes and their change years, and together with the 3 national land cover/land use maps, provides the basis for the annual matrices.

Figure 6.4 Change detection approach between reference years



The satellite based land monitoring system is planned to be continued and improved in the coming years.

Land Use Matrixes

Land uses and transitions between the 6 land use types and 11 land use subcategories have been calculated in annual land use/land use change matrixes for all 25 years (without any interpolation in between). Further, the last 6 years (2016 to 2022) have been extrapolated. All transitions are reported as transitions for 20 years following the transition event. Land categories and subcategories have been further disaggregated into 8 ecozones and 28 forest regional directorates. The ecozones have been explained above in Table 6.2. The outline of the core matrix is illustrated in Table 6.4.

Table 6.4 A sample land use matrix (2015)

TO: / FROM:	Forest land (managed)	Forest land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetlands (managed)	Wetlands (unmanaged)	Settlements	Other land	Total unmanaged land	Initial area
	(kha)										
Forest land (managed)(2)	22723.46	NO	4.37	4.41	NO	0.39	NO	0.44	2.16	NO	22735.23
Forest land (unmanaged)(2)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Cropland(2)	2.31	NO	26871.50	0.10	NO	1.86	NO	1.63	1.32	NO	26878.71
Grassland (managed)(2)	61.81	NO	5.32	23974.34	NO	1.06	NO	0.70	1.51	NO	24044.74
Grassland (unmanaged)(2)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Wetlands (managed)(2)	NO	NO	0.19	0.09	NO	465.68	NO	0.03	0.24	NO	466.23
Wetlands (unmanaged)(2)	NO	NO	NO	NO	NO	NO	1344.22	NO	NO	NO	1344.22
Settlements(2)	NO	NO	NO	NO	NO	0.00	NO	1383.70	0.01	NO	1383.71
Other land(2)	0.14	NO	0.46	0.18	NO	0.26	NO	0.06	1672.49	NO	1673.60
Total unmanaged land (3)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Final area	22787.72	NO	26881.83	23979.13	NO	469.25	1344.22	1386.55	1677.73	NO	78526.44
Net change(4)	52.50	NO	3.12	-65.61	NO	3.02	0.00	2.84	4.13	NO	0.00

Accuracy Assessment

For the land cover and land use datasets of the years 1990, 2000 and 2015, a scientifically sound thematic accuracy assessment has been carried out following best-practice standards according to ISO 19157 Geographic information - Data quality, the CEOS guidelines for Calibration and Validation and the QA4EO principles. This involves the following core design principles:

- Sampling design: A probability sampling design is used to generate a stratified random point sample that is statistically viable for all sampled categories and sub-categories at a confidence interval of 95%.
- Response design: The samples are then validated against higher quality data that includes aerial imagery (e.g. Google and Bing maps) for 2015; 15m pan-sharpened Landsat 7 imagery for 2000 and Landsat 5 imagery for 1990, in addition to other independent aerial or very high resolution satellite imagery, other map products or local auxiliary data.
- Analysis: The outcomes are presenting uncertainty measures on the area and area changes of the land use categories in the form of a confusion matrix (Table 6.5) that provides information on overall thematic accuracy, class-specific user's and producer's accuracies, and Kappa coefficients at a confidence interval of 95%. User accuracy and Producer accuracy are defined as follows:

User accuracy is a measure of commission error: Represents the probability that a pixel classified into a given category actually represents that category on the ground. Producer accuracy is a measure of omission error. This value represents how well reference pixels of the ground cover type are classified.

Table 6.5.a Confusion Matrix-1990

LANDCOVER TURKEY 1990

	REFERENCE / GROUND TRUTH													
CLASSIFICATION	Deciduous Forest	Coniferous Forest	Mixed Forest	Degraded Forest	Annual Crops	Perennial Crops	Herbaceous Cover	Managed Water	Unmanaged Water	Settlements	Other Land	Row Total	User's Accuracy	95% Confidence Interval
Deciduous Forest	**100**	7	3	3	2	0	0	0	0	0	0	115	86.96%	3.55%
Coniferous Forest	6	**124**	3	5	0	0	1	0	0	0	0	139	89.21%	2.90%
Mixed Forest	7	6	**85**	2	0	0	0	0	0	0	0	100	85.00%	4.14%
Degraded Forest	1	1	1	**93**	1	0	3	0	0	0	0	100	93.00%	2.70%
Annual Crops	0	1	0	1	**305**	0	8	0	0	0	3	318	95.91%	1.14%
Perennial Crops	2	3	0	0	4	**82**	3	1	0	1	4	100	82.00%	4.61%
Herbaceous Cover	6	5	0	12	2	1	**290**	0	0	3	6	325	89.23%	1.89%
Managed Water	1	0	0	0	0	0	3	**89**	2	0	5	100	89.00%	3.46%
Unmanaged Water	0	1	0	0	0	0	2	0	**96**	0	1	100	96.00%	2.01%
Settlements	0	1	0	0	1	0	12	0	0	**86**	0	100	86.00%	3.97%
Other Land	0	0	0	0	1	0	2	0	1	2	**94**	100	94.00%	2.49%
Column Total	123	149	92	116	316	83	324	90	99	92	113	**1597**		
Producers Accuracy	81.30%	83.22%	92.39%	80.17%	96.52%	98.80%	89.51%	98.89%	96.97%	93.48%	83.19%			
95% Confidence Interval	4.26%	3.62%	2.95%	4.54%	1.05%	1.20%	1.87%	1.10%	1.75%	2.71%	4.16%			

Overall Accuracy	90.42%

Table 6.5.b Confusion Matrix-2000

LANDCOVER TURKEY 2000

	REFERENCE / GROUND TRUTH													
CLASSIFICATION	Deciduous Forest	Coniferous Forest	Mixed Forest	Degraded Forest	Annual Crops	Perennial Crops	Herbaceous Cover	Managed Water	Unmanaged Water	Settlements	Other Land	Row Total	User's Accuracy	95% Confidence Interval
Deciduous Forest	**105**	4	1	2	0	0	2	0	0	0	1	115	91.30%	2.83%
Coniferous Forest	10	**114**	2	9	0	0	2	1	0	0	1	139	82.01%	3.91%
Mixed Forest	4	11	**83**	2	0	0	0	0	0	0	0	100	83.00%	4.46%
Degraded Forest	1	4	0	**93**	0	0	2	0	0	0	0	100	93.00%	2.70%
Annual Crops	0	0	0	2	**298**	0	14	0	0	1	3	318	93.71%	1.43%
Perennial Crops	6	0	0	0	5	**80**	5	0	0	4	0	100	80.00%	4.92%
Herbaceous Cover	2	2	1	0	4	2	**294**	0	1	2	17	325	90.46%	1.77%
Managed Water	0	1	0	0	0	0	3	**94**	0	1	1	100	94.00%	2.49%
Unmanaged Water	1	0	0	0	0	0	1	0	**94**	0	4	100	94.00%	2.49%
Settlements	2	0	0	0	1	1	10	0	0	**85**	1	100	85.00%	4.14%
Other Land	0	0	0	0	0	0	1	0	2	3	**94**	100	94.00%	2.49%
Column Total	131	136	87	108	308	83	334	95	97	96	122	**1597**		
Producers Accuracy	80.15%	83.82%	95.40%	86.11%	96.75%	96.39%	88.02%	98.95%	96.91%	88.54%	77.05%			
95% Confidence Interval	4.28%	3.71%	2.32%	3.80%	1.02%	2.10%	1.98%	1.04%	1.79%	3.62%	4.86%			

Overall Accuracy	89.79%

Table 6.5.c Confusion Matrix-2015

LANDCOVER TURKEY 2015

REFERENCE / GROUND TRUTH

CLASSIFICATION	Deciduous Forest	Coniferous Forest	Mixed Forest	Degraded Forest	Annual Crops	Perennial Crops	Herbaceous Cover	Managed Water	Unmanaged Water	Settlements	Other Land	Row Total	User's Accuracy	95% Confidence Interval
Deciduous Forest	**94**	4	3	12	0	1	2	0	0	0	0	116	81.03%	4.42%
Coniferous Forest	6	**118**	8	3	0	0	2	1	0	0	0	138	85.51%	3.45%
Mixed Forest	6	5	**88**	1	0	0	0	0	0	0	0	100	88.00%	3.64%
Degraded Forest	3	4	0	**81**	0	1	9	0	0	0	2	100	81.00%	4.77%
Annual Crops	1	1	0	1	**283**	2	31	0	0	0	0	319	88.71%	1.96%
Perennial Crops	3	1	1	2	10	**81**	0	0	0	0	2	100	81.00%	4.77%
Herbaceous Cover	3	3	0	0	15	4	**289**	0	0	0	10	324	89.20%	1.90%
Managed Water	0	0	0	0	0	0	0	**98**	2	0	0	100	98.00%	1.41%
Unmanaged Water	0	1	0	0	0	0	2	0	**96**	0	1	100	96.00%	2.01%
Settlements	0	0	1	0	0	3	5	0	0	**89**	2	100	89.00%	3.46%
Other Land	1	0	0	0	0	0	1	0	4	1	**93**	100	93.00%	2.70%
Column Total	117	137	101	100	308	92	341	99	102	90	110	**1597**		
Producers Accuracy	80.34%	86.13%	87.13%	81.00%	91.88%	88.04%	84.75%	98.99%	94.12%	98.89%	84.55%			
95% Confidence Interval	4.50%	3.37%	3.77%	4.77%	1.66%	3.79%	2.25%	1.00%	2.44%	1.10%	4.01%			

Overall Accuracy	88.29%

Completeness

As regards the inventory completeness, sinks and sources that have been reported with notation keys NA, NO, IE and NE in the CRT tables are listed below:

Table 6.6 Completeness Table

Sink/source category	Pool	GHG	Reported as	Mandatory	Explanation
Forest land remaining forest land	Soil	CO_2	NO	No	It is assumed that carbon stocks of soils in Forest Land Remaining Forest Land do not change.
Forest land remaining forest land	Dead wood and litter	CO_2	NO	No	It is assumed that carbon stocks of DOM in Forest Land Remaining Forest Land do not change.
Land converted to Forest land	Dead wood	CO_2	NO	Yes	Land converted to Forest Land areas are afforestation areas. Trees in these areas are not measured in forest inventory due to trees with diameter at breast height of lower than 8 cm and that are under 20 years old by Forest Management and Planning Department of OGM. The DW carbon stocks in case of land conversion are assumed to be not changing and DW carbon stocks in all land use are assumed to be zero.
Forest land, Biomass Burning-Controlled Burning	Biomass	CO_2, CH_4 and N_2O	NA	Yes	Controlled Burning is not applied in Forest land.
Forest lands, drained soils	Biomass	Non-CO_2	NA	Yes	No available data on drainage
Drained wetlands	Biomass	Non-CO_2	NO	Yes	Wetland drainage is not performed in Türkiye.
Croplands, grasslands, wetlands and settlements, biomass burning	Biomass	CO_2, CH_4 and N_2O	NA,NO,IE	Yes	No available data

6.2. Forest Land (4.A)

Source Category Description:

The forest land category includes CSC from Forest Land Remaining Forest Land (FL-FL) and Land Converted to Forest Land (L-FL) subcategories. Tier 2 methods that are combinations of national EFs and IPCC methods have been applied except for some default coefficients (i.e. CF, root to shoot ratio). The AD in these subcategories have entirely been changed. The previous submissions used to base on ENVANIS statistics for AD and increment values. With the spatially explicit land tracking system the increment values are taken from Forestry Statistics but AD has entirely been changed. The improvements in this category with the new reporting system and consequences are as follows;

- The forest definition has been changed to one that is more suitable for GHG inventories. The previous national definition was a legal definition that do not include a threshold for crown closure. All land uses have been disaggregated into ecozones but forests have also been split into 28 regional forestry directorates. This will enable to implementation of mitigation actions more effectively among forestry directorates.
- Now the forest land has been split into 4 subcategories that are coniferous, deciduous, mixed forest and other forested land (OFL). OFL are forest areas with crown closure between 1 to 10 percent. The previous forest definition included a minimum area of 3 ha. The new system defines all forests with a minimum area of 1 ha.
- The previous system was based on Forestry Statistics which was available since 2007. The period before 2007 was extrapolated basis on 1972 and 1999's forest inventory. With the new system, consistent land use and land use change AD has been available for the whole reporting period. The AD base on satellite images and has 1 ha spatial resolution.
- The previous system was not able to identify land conversions between forests and other land uses (i.e. L-FL, FL-CL, FL-GL) and it was assumed that conversions occur only from and to grasslands. Now all land conversions have been tracked with high accuracy and emissions/removals have been reported.
- The previous system was based on reports from regional forestry districts and was not subject to verification while the new system enables verification of the satellite based maps from other sources (i.e. Land Parcel Identification System, CORINE).
- The crown closure data from Forestry Statistics was based on subjective observations while the new system enabled objective automatic identification.

- The AD of the previous system was derived from the management unit of GDF while AD has been produced by an international remote sensing company. This strengthens the objectiveness of the AD.
- As a consequence of changes in definition and AD development methodology, the total forest did not change significantly but productive forest areas that have crown closure of more than 10 percent increased significantly. As a result of this, the removals due to the increase in aboveground biomass increased drastically. The increment data taken from Forestry Statistics puts forward large increases in increment between 2011 and 2018 which may be caused by rehabilitation projects in the early 2000s. The productivity of the stands increased as the stands reached the fast-growing young ages in the 2010s. The changes in increment for forest types are given below;

Table 6.7 Annual increment rates of forest types in Türkiye

(m^3/ha)

Year	Deciduous	Coniferous	Mixed	OFL
1990	3.15	2.99	3.07	0.26
1995	3.20	3.03	3.11	0.27
2000	3.25	3.08	3.16	0.27
2005	3.30	3.13	3.21	0.23
2010	3.35	3.39	3.37	0.22
2011	3.48	3.45	3.47	0.21
2012	3.48	3.45	3.47	0.21
2013	3.48	3.45	3.47	0.21
2014	3.48	3.45	3.47	0.21
2015	3.25	3.56	3.40	0.22
2016	3.25	3.56	3.40	0.22
2017	3.25	3.56	3.40	0.22
2018	3.27	3.58	3.42	0.22
2019	3.27	3.56	3.41	0.21
2020	3.22	3.53	3.38	0.21
2021	3.17	3.49	3.33	0.21
2022	3.20	3.42	3.31	0.20

Information on Land Classification and Activity Data

Detailed information has been provided under section 6.3.

Land-use definitions and the classification systems

In the previous submissions before 2019 national forest definition was used. With the 2019 submission, the forest definition has been changed to a definition in line with the definitions of the Food and Agriculture Organization of the United Nations. The EU and FAO compliant forest definition of 10% crown cover, 1 ha MMU and 5m tree height is applied to all sub-categories. The lands below 10 percent crown closure are classified under other forested land (OFL) as a subcategory under forest land. Agriculturally used tree crops are classified under perennial croplands and are not part of the forest definition.

The forests have further been classified as coniferous, deciduous and mixed forests. The mixed forests consist of both coniferous and deciduous trees with neither species clearly dominating the stand.

Table 6.8.a Forest area (kha) changes in Türkiye, 1990-2022

	Tabular (old system)			Spatially explicit land tracking (new system)		
Year	Productive forest	Other Forested Land	Total	Productive forest	Other Forested Land	Total
1990	10 494	10 075	20 569	19 721	3 258	22 979
1995	10 546	10 125	20 672	19 699	3 248	22 955
2000	10 643	10 218	20 861	19 664	3 242	22 908
2005	10 662	10 586	21 248	19 637	3 218	22 865
2010	11 203	10 334	21 537	19 583	3 184	22 783
2015	12 704	9 639	22 343	19 606	3 181	22 787
2016	12 704	9 639	22 343	19 658	3 182	22 840
2017	12 983	9 638	22 621	19 583	3 183	22 766
2018	12 983	9 638	22 621	19 602	3 184	22 786
2019	13 083	9 656	22 740	19 610	3 184	22 794
2020	13 264	9 668	22 933	19 603	3 194	22 797
2021	13 500	9 610	23 110	19 800	3 220	23 020
2022	13 708	9 537	23 245	19 810	3 221	23 031

Table 6.8.b Forest types distribution as area (kha) according Spatially Explicit tracking system in Türkiye, 1990-2022

kha

Year	Coniferous	Deciduous	Mixed	OFL	Total
1990	10374	8612	729	3256	22971
1991	10374	8612	729	3256	22970
1992	10374	8612	729	3256	22970
1993	10373	8611	730	3255	22970
1994	10373	8611	731	3255	22970
1995	10372	8611	732	3255	22970
1996	10371	8611	733	3255	22969
1997	10370	8610	734	3255	22969
1998	10369	8610	735	3255	22969
1999	10368	8610	737	3254	22969
2000	10367	8608	739	3254	22969
2001	10366	8608	740	3252	22967
2002	10364	8607	744	3247	22962
2003	10360	8605	750	3243	22959
2004	10357	8604	756	3237	22953
2005	10352	8600	765	3232	22950
2006	10348	8597	772	3225	22943
2007	10341	8594	784	3220	22939
2008	10335	8590	794	3213	22933
2009	10329	8586	806	3209	22929
2010	10323	8582	818	3201	22924
2011	10316	8578	830	3197	22921
2012	10306	8575	844	3193	22919
2013	10298	8573	857	3189	22918
2014	10290	8571	869	3186	22917
2015	10280	8568	883	3184	22915
2016	10348	8597	824	3225	22995
2017	10341	8594	833	3220	22988
2018	10335	8590	841	3213	22980
2019	10329	8586	850	3209	22973
2020	10323	8582	858	3201	22964
2021	10316	8578	929	3197	23020
2022	10306	8575	957	3193	23031

The increment data is provided by the Management Department of the Forest Service (GDF) via Forestry Statistics. The Forestry Statistics database collects and processes data from forest management plans as the plans are renewed every ten years. Since 2007, the Forestry Statistics database, a forest resources inventory based on forest management units is used. This database covers the data of areas, annual increment, commercial volume and growing stock of each forest management unit by the species, management types, form of stand, purpose, etc. Therefore, a comparison of forest area, annual increment and growing stock, between two subsequent years, has been possible since 2007. The comparison of removals by forestry sector, according to the forest area, growing stock changes and annual increment since 1990 is given in Table 6.8.a-b, 6.10 and 6.11.

Databases to Identify Forests

There are only two documents (1972 and 1999 inventory) relevant to the national forest inventory results in Türkiye before 2002. The first document showing the 1972 situation was presented in 1980, and the second was prepared at the end of 1999. Because of the absence of regular national forest inventory works in Türkiye, both of the results were obtained based on the summaries of management plans data renewed every ten years interval. The data provided by the first inventory (1972) has been shown in Table 6.9. The growing stock and annual increment data since 1990 have been presented in Tables 6.10 and 6.11.

Table 6.9 Forest inventory, 1972 (Source: GDF)

Areas						
	Productive[a]		**Degraded[b]**		**Total**	
Type	**ha**	**%**	**ha**	**%**	**ha**	**%**
High Forest	6 176 899	30.58	4 757 708	23.55	10 934 607	54.13
Coppice	2 679 558	13.27	6 585 131	32.60	9 264 689	45.87
Total	8 856 457	43.85	11 342 839	56.15	20 199 296	100.00
Growing stock						
	Productive[a]		**Degraded[b]**		**Total**	
Type	**m^3**	**%**	**m^3**	**%**	**m^3**	**%**
High Forest	758 732 197	81.10	54 349 847	5.81	813 082 044	86.91
Coppice[c]	88 300 818	9.44	34 129 288	3.65	122 430 106	13.09
Total	847 033 015	90.54	88 479 135	9.46	935 512 150	100.00
Annual volume increment						
	Productive[a]		**Degraded[b]**		**Total**	
Type	**m^3**	**%**	**m^3**	**%**	**m^3**	**%**
High Forest	20 791 672	74.09	1 343 744	4.79	22 135 416	78.88
Coppice[c]	4 813 197	17.15	1 114 592	3.97	5 927 789	21.12
Total	25 604 869	91.24	2 458 336	8.76	28 063 205	100.00

a) Crown closure between 0.11–1.00.
b) Crown closure between 0.01–0.10.
c) 0.75 coefficient was used to convert the stere volume to a m^3 volume.

Table 6.10.a Growing stock, 1990-2022 (Source: GDF)

(thousand m³)

	Productive[1]			Degraded[2]			
Year	High Forest	Coppices[3]	Productive total	High Forest	Coppices[3]	Degraded total	Total
1990	984 907	64 986	1 049 893	43 622	12 038	19 976	1 105 553
1995	1 028 346	67 957	1 096 303	45 618	12 589	20 890	1 154 509
2000	1 087 582	72 002	1 159 584	48 334	13 338	22 134	1 221 256
2005	1 177 849	71 551	1 249 400	51 045	12 661	23 655	1 313 106
2010	1 328 437	59 097	1 387 534	49 351	12 286	19 415	1 449 171
2015	1 552 821	33 695	1 586 516	59 997	11 954	71 951	1 658 467
2016	1 540 723	29 215	1 569 939	60 895	10 377	71 271	1 641 210
2017	1 601 931	13 728	1 615 659	64 991	4 314	69 306	1 684 964
2018	1 601 931	13 728	1 615 659	64 991	4 314	69 306	1 684 964
2019	1 595 828	14 013	1 609 841	64 791	4 723	69 514	1 679 356
2020	1 614 281	14 013	1 628 295	64 037	4 722	68 759	1 697 055
2021	1 639 227	14 013	1 653 240	63 731	4 722	68 454	1 721 695
2022	1 656 186	12 053	1 668 239	64 870	3 292	68 162	1 736 402

1) Crown closure between 0.11–1.00.
2) Crown closure between 0.01–0.10.
3) 0.75 coefficient was used to convert the stere volume to a m3 volume.

Table 6.10.b Annual volume increment, 1990-2022 (Source: GDF)

(m³)

	Productive[1]			Degraded[2]			
Years	High Forest	Coppices[3]	Productive total	High Forest	Coppices[3]	Degraded total	Total
1990	28 263 488	3 594 725	31 858 213	1 292 180	761 076	2 053 256	33 911 468
1995	28 997 951	3 697 360	32 695 311	1 329 099	782 820	2 111 919	34 807 230
2000	31 047 474	3 985 847	35 033 320	1 432 875	843 943	2 276 819	37 310 139
2005	33 282 485	4 025 038	37 307 523	1 495 502	922 183	2 417 685	39 725 208
2010	37 857 085	3 089 208	40 946 293	1 468 070	792 878	2 260 948	43 207 241
2015	46 011 103	1 511 832	47 522 935	1 484 455	585 191	2 069 646	49 592 580
2016	43 669 510	1 277 030	44 946 540	1 539 688	487 331	2 027 019	46 973 559
2017	45 516 439	755 697	46 272 136	1 728 694	252 728	1 981 422	48 253 588
2018	44 247 096	762 981	45 010 077	1 713 433	276 490	1 989 923	47 000 000
2019	44 447 096	762 981	45 210 077	1 713 433	276 490	1 989 923	47 200 000
2020	44 647 096	762 981	45 410 077	1 713 498	276 425	1 989 923	47 400 000
2021	44 863 388	762 981	45 626 369	1 697 206	276 425	1 973 631	47 600 000
2022	45 183 944	678 743	45 862 687	1 727 867	209 446	1 937 313	47 800 000

1) Crown closure between 0.11–1.00 (productive forest).
2) Crown closure between 0.01–0.10 (degraded).
3) 0.75 coefficient was used to convert the stere volume to a m3 volume.

Table 6.11 Felling statistics, 1990-2022 (Source: GDF)

	Industrial Roundwood (1000 m³)			Firewood (1000 stere)[1]					Illegal Logging (1000 m³)			1000 m³
Years	Coniferous	Deciduous	Coppices	Coniferous (Trunk)	Coniferous (Branch)	Deciduous (Trunk)	Deciduous (Branch)	Coppices (Stem)	Coniferous	Deciduous	Coppices	TOTAL
1990	5,067.4	1513.6	0.0	1533.2	1563.8	368.0	345.9	5297.8	17.6	3.9	56.5	13490.6
1995	6,584.7	1459.9	415.1	1196.7	1220.6	904.4	850.1	2982.7	19.7	14.2	46.8	13906.3
2000	5,755.1	1574.2	976.2	1046.9	1475.0	1081.6	1202.7	3055.3	12.0	11.4	32.2	14257.2
2005	6,258.1	1842.2	1224.7	1373.6	1486.9	1264.3	1091.1	2451.2	9.7	8.4	16.2	15109.6
2010	9,502.0	3066.5	0.0	1545.7	1348.8	1156.2	1357.0	1786.7	6.8	4.8	7.4	17983.3
2015	12,807.2	3830.4	0.0	1049.0	1277.9	1117.3	547.2	1181.7	5.0	5.2	5.5	20533.1
2016	12,715.4	4294.6	0.0	1210.7	992.7	984.7	618.5	1070.5	5.8	4.5	4.9	20683.1
2017	11,486.0	4035.6	0.0	1024.9	901.7	972.1	601.8	859.1	6.5	5.9	5.2	18809.0
2018	13,918.1	5162.0	0.0	1279.8	1162.9	1074.6	594.6	778.6	8.4	6.9	5.0	22768.2
2019	16,252.8	5860.5	0.0	1549.1	1236.5	1274.5	591.7	938.0	11.1	8.9	6.6	26332.1
2020	18,087.1	6664.0	0.0	1519.7	1236.7	1420.8	396.4	823.1	21.7	20.0	11.6	28851.9
2021	20,917.2	6818.0	0.0	1945.4	781.0	1520.0	287.4	953.5	15.9	12.2	7.7	31886.6
2022	19,018.7	6462.3	0.0	2115.9	858.4	1327.8	313.2	1513.5	21.1	13.0	14.8	30126.6

1) 0.75 coefficient was used to convert the stere volume to a m³ volume.

Evaluation of Table 6.9, 6.10.a, 6.10.b, and 6.11 can be outlined as below:

1. The growing stocks and annual volume increments of the coppice forests reduced while high forests increased constantly. The highest amount of decrease in growing stock/annual increment has occurred in degraded coppices due to converting the coppices into high forests.

2. The total amount of growing stocks and annual volume increment in the coniferous and deciduous forests per hectare have slightly decreased.

   The considerable reasons for these changes can be:

1. The changing approaches on the forestry applications towards multi-functional use of forest resources in the framework of sustainable forest management concept,
2. Converting coppices into the high forests,
3. The reforestation of unstocked areas in and around forests and rehabilitation of degraded forests by the GDF.

4. Intense harvest policies due to salvage logging also caused decreasing in annual increment values per hectare.

All the factors focused on above have played an affecting role in these changes. Almost entire of Turkish forests can be categorized in the temperate climate zone.

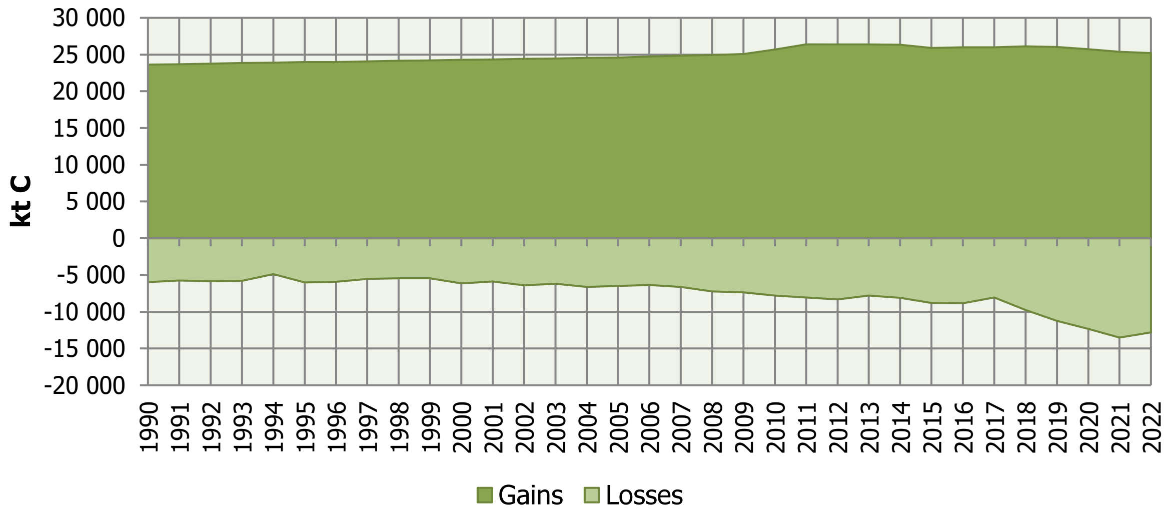
CSC in Forest Land Remaining Forest Land

The carbon stock change in FL-FL subcategory has been net removals during the reporting period. The driver of this situation was the annual increment of forests. The increment of the forests in the country increased for the reporting period constantly while increased faster for some years. The steep increase between 2009 and 2019 was due to the difference in increment (m^3/ha) for 2014 (Iv_{dec}=3.26, Iv_{con}=3.31, Iv_{mixed}=3.29, Iv_{deg}=0.22) and 2019 (Iv_{dec}=3.27, Iv_{con}=3.56, Iv_{mixed}=3.41, Iv_{deg}=0.21). This might have been caused by extensive rehabilitation campaigns during the 2000s. However, after 2019, annual increment values have been decreasing due to most of the natural disturbances related with climate change and intensive wood harvesting activities being applied in productive forests. The increment data is derived from all management units of the country as explained in the methodology section.

There is only biomass carbon pool evaluated in the estimation of the carbon stock change in FL-FL subcategory. The main approach for other pools is Tier 1 approach in the IPCC 2006 Guidelines which means there no change in the carbon stocks of these pools.

The removals of the forest land remaining forest land subcategory have been decreased for the last 3 years. The main reason is the increase of the fellings for industrial roundwood is salvage logging. The industrial roundwood production amounts have been increased respectively by 19 million m^3 for 2017 to 22 million m^3 for 2018, 26 million m^3 for 2019, 28 million m^3 for 2020, 32 million m^3 for 2021 and 30 million m^3 for 2022 (Table 6.11). In addition, approximately 10 million CO_2 eq. emission estimated for Forest Land Remaining Forest Land category due to mega fire in 2021 in Türkiye.

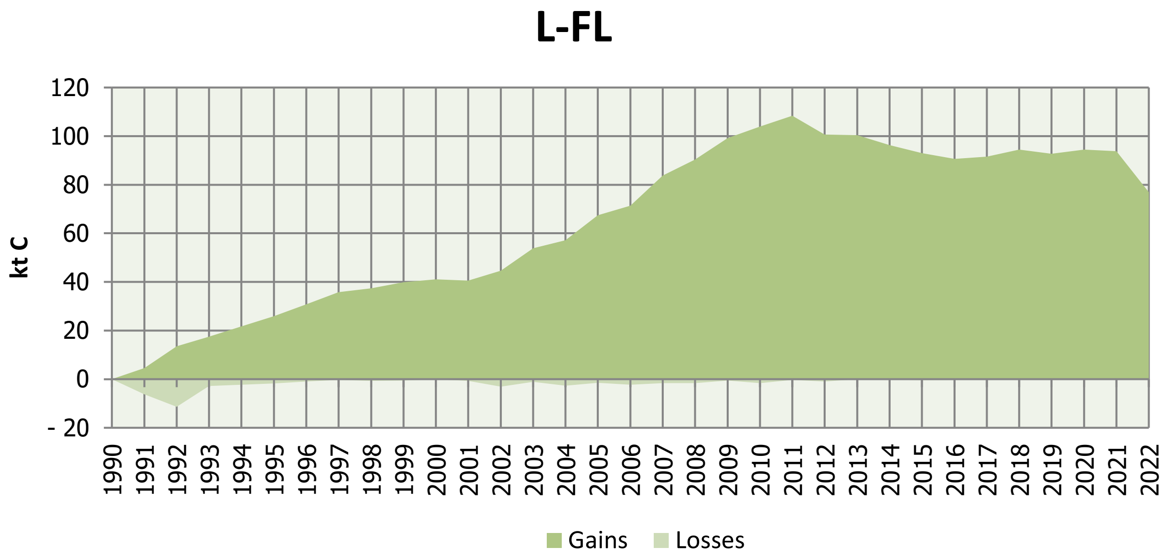
Figure 6.5 Gains and losses in Forest land Remaining Forest land subcategory (FL-FL)



CSC in Land Converted to Forest Land

The CSC in Land Converted to Forest land category is not a key category anymore with the new reporting system. The main reason for the drop in L-FL removals is due to a change in forest definition. As explained in the section 6.2 the forest definition has been changed to a physical definition while it used to be a legal national definition. As a consequence of this, the AD for land converted to forest land decreased substantially. The CSC in L-FL subcategory moved from net loss to net gain during the reporting period through large fluctuations are observed (Figure 6.6). The large loss in CSC in 1992 was due to a relatively larger conversion from grassland to forest. As explained in the methodology section below the conversion from grassland to forest land causes a loss in living biomass carbon for the first year.

Figure 6.6 Gains and losses in Land Converted to Forest land subcategory (L-FL)

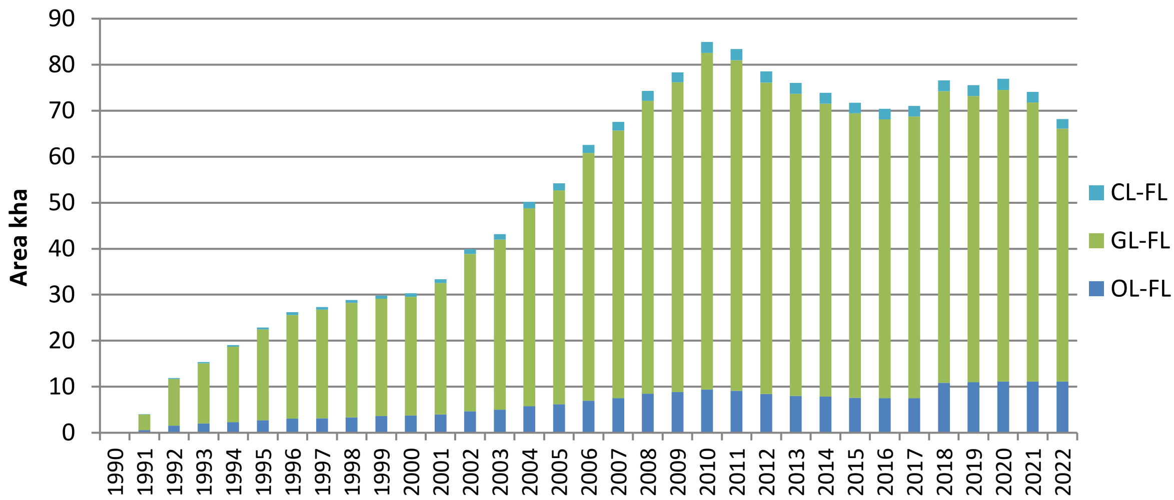


As seen from the graph above (Figure 6.6) the L-FL gains increased until 2011 and stabilized since then. There have been 3 types of transitions that occurred during the reporting period;

- Grassland Converted to Forest land
- Other land Converted to Forest land
- Cropland (Perennial) Converted to Forest land

Between 1991 and 1996 the conversions were around 4000 ha per year, then dropped below 2000 between 1997 to 2000 and then rise again until 2017. The great increase trend in land conversion to forest between the years 2011 to 2017 and 2020 to 2022 caused from great afforestation campaigns.

Figure 6.7.a Area data for Land Converted to Forest land subcategory



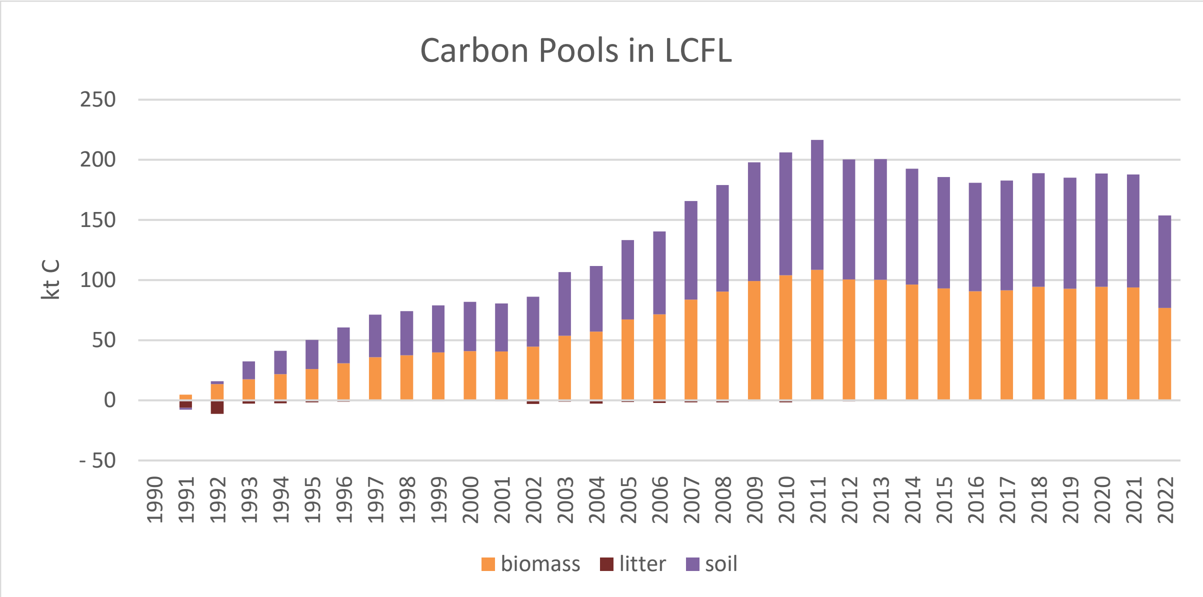
As seen in Figure 6.7.a the major conversion path in L-FL subcategory is the conversion from Grassland to Forest land. The driver of this conversion type is the afforestation/reforestation of grasslands in or around the forests.

Table 6.12 Area of Land converted to forest land

(kha)

Year	GL-FL	CL-FL	OL-FL	Year	GL-FL	CL-FL	OL-FL
1990	0.00	0.00	0.00	2007	58.15	1.93	7.51
1991	3.40	0.07	0.56	2008	63.66	2.10	8.52
1992	10.11	0.21	1.56	2009	67.29	2.20	8.86
1993	13.08	0.29	2.01	2010	73.13	2.38	9.42
1994	16.36	0.37	2.33	2011	71.88	2.39	9.11
1995	19.69	0.47	2.74	2012	67.73	2.38	8.40
1996	22.58	0.57	3.04	2013	65.63	2.35	8.03
1997	23.60	0.60	3.15	2014	63.68	2.32	7.87
1998	24.83	0.67	3.38	2015	61.81	2.31	7.60
1999	25.47	0.73	3.65	2016	60.60	2.30	7.49
2000	25.77	0.76	3.76	2017	61.16	2.34	7.55
2001	28.54	0.83	4.00	2018	63.37	2.35	10.84
2002	34.21	1.05	4.68	2019	62.16	2.36	11.00
2003	36.98	1.15	5.03	2020	63.37	2.41	11.16
2004	43.05	1.39	5.77	2021	60.60	2.34	11.16
2005	46.52	1.54	6.17	2022	54.93	2.13	11.16
2006	53.87	1.76	6.94				

Figure 6.7.b CSC of Carbon Pools in Land Converted to Forest land subcategory



As seen in Figure 6.7.b of the distribution CSC of Carbon Pools in Land Converted to Forest land subcategory half of removals (%50) are derived from biomass carbon pool and 49% of removals are derived from soil carbon pool. Litter carbon pool only consist of 1 % of this subcategory' removals. Land converted to Forest Land areas are afforestation areas. Trees in these areas are not measured in forest inventory due to trees with diameter at breast height of lower than 8 cm and that are under 20 years old by Forest Management and Planning Department of OGM. The DW carbon stocks in case of land conversion are assumed to be not changing and DW carbon stocks in all land use are assumed to be zero. The biomass of afforestation areas is calculating by modelling from young stands.

Methodological Issues:

Forest Land Remaining Forest land

The calculations in FL category are based on 8 ecozones and 28 forestry regional directorates. The soil C stocks for each ecozone have been calculated by TAGEM (General Directorate of Agricultural Research) based on the soil database since the 2019 submission.

It is explained in Section 6.3 Croplands (Mineral and organic soils).

Above- and below-ground biomass

Gain-Loss Method (Tier 2) is used to estimate annual change in carbon stocks in living above- and below-ground biomass, considering the country-specific data on mean annual increment, volume of commercial cutting, fuelwood removal and loss due to disturbances, national biomass expansion factors

($BCEF_I$, $BCEF_R$) and basic wood densities (D), and default root-to-shoot ratios (R) and carbon fractions (CF). The below equations have been used in estimations;

2006 IPCC equations: Vol 4., Ch. 2: 2.7 / 2.9 / 2.10 / 2.11 / 2.12 / 2.13 / 2.14
The estimation approach was as follows;

i. The area of each forest stratum with corresponding mean annual increment has been multiplied by national BCF_I coefficients, IPCC 2006 default root-to-shoot ratios, and IPCC 2006 default CF coefficients to get annual biomass gain (ΔC_G).

The increment data is provided by the Forest Management Department via the ENVANIS system and they are updated every year for four forest types;

- Deciduous forest
- Coniferous forest
- Mixed forest
- Degraded forest

The increment data used are given in Table for some years.

ii. Annual carbon loss (ΔC_L) as a sum of wood removals (i.e. commercial cutting), fuelwood removal and disturbance (i.e. forest fires) by each forest stratum has been calculated. In the calculation of annual carbon losses in biomass due to disturbances ($D_{isturbance}$), the annual area affected by disturbances has been used (see Equation 2.14).

The data used in this step is received from relevant departments (Production and Marketing, Fire etc.) of the GDF.
The annual biomass loss is a sum of losses from commercial round wood felling, fuelwood gathering and other losses in forest land was calculated by using the following Equation 2.11 of AFOLU Guidance. Biomass gains and biomass losses are estimated separately. For example, commercial round wood felling has been calculated in a different column as well as fuelwood gathering and other losses according to Equation 2.12, Equation 2.13 and Equation 2.14 respectively. The calculations of biomass losses are consistent with the IPCC 2006 Guidance for AFOLU (Vol 4).

2006 IPCC equations: Vol 4., Ch. 2: 2.11 / 2.12 / 2.13 / 2.14 / 2.17 /2.24 / 2.27

The FG data in eq. 13 is obtained from the GDF (Forestry Statistic 2022). According to GDF's data, percentage of the illegal cutting is 67, also the fuelwood gathering is 33.

In eq. 2.14 to calculate the losses from wildfires the BW covers the dead organic matter. It is assumed that all dead organic matter is burned in wildfires in this category. It is also assumed that average biomass during wildfires is burned with 44 percent of burning productivity (GDF 2008-2016).

iii. All biomass gains and losses have been summed up from strata to get estimates for FF.
iv. Annual change in carbon stock in biomass has been estimated as a difference between ΔC_G and ΔC_L.

Table 6.13 The Average basic wood density and national BCEF's factors (Tolunay, 2013)

Vegetation type	Basic wood density (tonnes/m³)	$BCEF_I$ (tonnes/m³)	$BCEF_S$ (tonnes/m³)	$BCEF_R$ (tonnes/m³)
Coniferous	0.446	0.541	0.563	0.612
Deciduous	0.541	0.709	0.717	0.797

Soil and dead organic matter

Currently, no changes in CSC in deadwood, litter and soil (Tier 1 assumption) are reported due to lack of data related to any change in soil and DOM carbon stocks in FL-FL.

Land Converted to Forest land

The annual increments and coefficients used for Land Converted to Forest Land were;

Table 6.14 Coefficients used to calculate CS and CSC in L-FL

Forest Type	Annual Increment m³/ha	$BCEF_I$	Root to Shoot Ratio tonnes d.m. below-ground biomass/tonnes above-ground d.m. biomass	CF tonnes C/tonnes dm
Forest Deciduous	0.69[1]	0.709[2]	0.46[3]	0.48[3]
Forest Coniferous	0.69[1]	0.541[2]	0.40[3]	0.51[3]
Forest Mixed	0.69[1]	0.625[2]	0.48[3]	0.47[3]
Forest Degraded	0.69[1]	0.625[2]	0.44[3]	0.47[3]

[1]Forest Management Department
[2]Tolunay (2013)
[3]IPCC 2006

The conversion period is accepted as 20 years. It is assumed that there is no change in the dead wood carbon stocks for land converted to forest land categories.

The DOM C stock is assumed to accumulate in 20 years conversion time to reach a steady state given in Table 6.15 below (Tolunay and Çömez, 2008) :

Table 6.15 Carbon stocks in DOM used for all forest areas in Türkiye

DOM (tonnes/ha)		
Coniferous	7.51	± 6.61 (n=601)
Deciduous	3.09	± 1.58 (n=368)

The below soil C stock values have been applied in case of land use conversions. The stock values have been calculated by the Research Units of Ministry of Agriculture and Forestry.

Table 6.16 SOC stocks of forests disaggregated for ecozones

Ecozone	C stock Forest land (tC/ha)	SOC ref
Mediterranean Mountain zone	51.53	46.96
Mediterranean coastal zone deciduous and coniferous forest	46.08	37.77
East Anatolian steppe	48.41	47.99
East Anatolian deciduous forest zone	45.14	41.30
Euxine-Colchic deciduous forest	51.90	49.66
Central Anatolian steppe	49.92	40.41
Aegean Inland deciduous and coniferous forest	50.88	42.53
North Anatolian deciduous, coniferous and mixed forest	55.05	54.57

Reference to the 2006 IPCC equations: Vol 4., Ch. 2: 2.16 / 2.19

Uncertainties and Time-Series Consistency:

According to para 15 of 24/CP19 Annex I Parties shall quantitatively estimate the uncertainty of the data used for all source and sink categories using at least Approach 1, and report uncertainties for at least the base year (1990) and last reported year (2022), as well as the trend uncertainty between these two years.

There are two approaches presented in the 2006 IPCC guidelines, which use simple error propagation equations and Monte Carlo or similar techniques, respectively. The first approach has been used with the equations IPCC (2006) equations: Vol. 1, Ch. 3: 3.1 / 3.2.

Uncertainty of input data is provided by underlying systems. Uncertainty of activity data is derived for 11x11 land categories for the latest reported year 2015. Under the current stage of finalization of land use mapping, still, preliminary values of the uncertainty of activity data are estimated in the range of 5% for land remaining in the same category and 10% for land being in conversion among various land categories.

Uncertainty (in %, consistent with 2006 IPCC Guidelines) for CSCs is provided according to various underlying national sources and references.

Uncertainty propagation tracks GHG inventory calculation, i.e. from the most detailed input activity data and CSC/EF to GHG estimates at the land use subcategory and LULUCF sector. Uncertainty is propagated following Tier 1 with Eq. 3.2 of 2006 IPCC Guidelines where uncertain data is added or subtracted, and Eq. 3.1 of 2006 IPCC Guidelines where uncertain data is multiplied or divided.

Estimation of GHG inventory uncertainty covers completely the national territory for the year 1990 as the base year and last reported year (2022). Wherever CSC in a C pool is reported as NO or NA such estimates are not included in the Tier 1 propagation of uncertainty.

For all C pools subject to 20 year transition the uncertainty estimation considers aggregation of two terms:

a) uncertainty associated with the CSC for the area in the first year of the conversion which involves the uncertainty of C stocks in land use from before and after conversion, and the uncertainty of CSC in the first year after the conversion, and,

b) uncertainty for the rest of the area reported under respective conversion cumulated from previous years.

Table 6.17 shows the relative uncertainty for CSC overall for land subcategories.

Table 6.17 Uncertainty calculation results for the whole LULUCF sector

Summary	BY* (1990)	LRY** (2022)
4A1	51%	50%
4A2	0%	57%
4B1	7%	10%
4B2	0%	47%
4C1	0%	0%
4C2	0%	149%
4D1	0%	0%
4D2	0%	86%
4E1	0%	0%
4E2	0%	26%
4F1	0%	0%
4F2	0%	18%
Table 4(I)	0%	0%
Table 4(II)	0%	0%
Table 4(III)	0%	75%
Table 4(IV)	0%	387%
Table 4(V)	54%	54%
LULUCF sector	**50.80%**	**51.14%**

*BY: Base Year ; ** LRY:Last Reported Year

The summary table for the uncertainty in Forest land categories (FL-FL and L-FL) is as follows;

Table 6.18 Uncertainty summary table for Forest land subcategories

	BY (1990)	**LRY (2022)**
Forest land Remaining Forest land		
4A1 – FL-FL	51%	50%
ΔCC in Living Biomass	51%	50%
Annual Loss Living Biomass (ΔCL)	33%	34%
Annual Gain Living Biomass (ΔCG)	35%	35%
Net C stock change in Litter (ΔCC)	NA	NA
Net C stock change in Dead Wood (ΔCC)	NA	NA
Net C stock change in SOM (ΔCC)	NA	NA
Land Converted to Forest land		
4A2 – L-FL	0%	57.1%
ΔCC in Living Biomass	NA	4.9%
Annual Loss Living Biomass (ΔCL)	NA	22.6%
Annual Gain Living Biomass (ΔCG)	NA	4.9%
Net C stock change in Dead Wood (ΔCC)	NA	NA
Net C stock change in Litter (ΔCC)	NA	300.7%
Net C stock change in SOM (ΔCC)	NA	47.0%

Two forest inventories were carried out by the GDF for 1972 and 1999. Forestry Statistics has been started since 2007. The data on growing stocks and annual increments during the 1990-2007 period were calculated by interpolation among data from these three inventories (1972, 1999 and 2007). Thus, the annual increases of growing stocks and volume increments were assumed as linear. The Forestry Statistics tables have been published annually by GDF since 2007.

The time series consistency of area data has been significantly increased by using the same satellite images and methods as explained above. The statistics on the forest fires and commercial round wood production for the same period and fuelwood gathering data were also provided by Forestry Statistics.

Source-Specific QA/QC and Verification:

The QA/QC procedure has been realized in the framework of a plan developed and carried out by TurkStat the national inventory agency. The sector specific QA/QC has been realized by the LULUCF experts in and out of the agencies.

Recalculation:

The Forest Land Category was recalculated due to the change of the carbon fraction value of the mixed and degraded forest by recommendation of the ERT. All the changes by recalculating are demonstrated in Table 6.19.

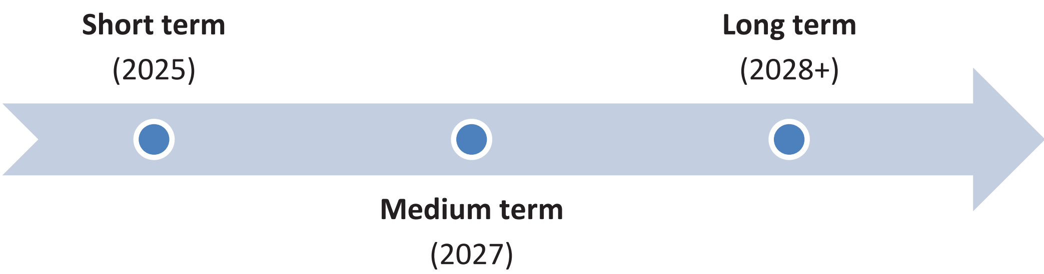
Table 6.19 Changes by the recalculation of Forest Land Remaining Forest Land subcategory

Year	Old Values (ktonnes CO2)	Recalculated Values (ktonnes CO2)	Changes(%)
1990	-63 604.96	-63 481.92	-0.19
1991	-65 080.08	-65 078.43	-0.00
1992	-64 723.50	-64 721.23	-0.00
1993	-64 854.30	-64 850.78	-0.01
1994	-66 605.68	-66 596.02	-0.01
1995	-65 327.37	-65 325.98	-0.00
1996	-65 327.89	-65 140.62	-0.29
1997	-67 725.27	-67 539.17	-0.27
1998	-68 223.84	-68 036.94	-0.27
1999	-68 690.78	-68 503.32	-0.27
2000	-64 375.54	-64 182.88	-0.30
2001	-67 313.82	-67 127.92	-0.28
2002	-65 536.58	-65 351.89	-0.28
2003	-66 806.09	-66 622.49	-0.27
2004	-65 608.20	-65 426.96	-0.28
2005	-66 598.59	-66 418.61	-0.27
2006	-66 926.69	-66 745.27	-0.27
2007	-66 142.25	-65 959.25	-0.28
2008	-62 383.80	-62 194.71	-0.30
2009	-65 078.58	-64 896.98	-0.28
2010	-65 874.37	-65 690.58	-0.28
2011	-67 507.44	-67 320.99	-0.28
2012	-65 695.42	-65 506.82	-0.29
2013	-67 473.50	-67 285.61	-0.28
2014	-67 109.02	-66 922.38	-0.28
2015	-62 936.81	-62 751.32	-0.29
2016	-62 370.60	-62 383.33	0.02
2017	-65 323.21	-65 285.54	-0.06
2018	-60 188.20	-60 081.79	-0.18
2019	-53 999.27	-53 815.54	-0.34
2020	-48 220.49	-47 923.84	-0.62
2021	-33 945.45	-33 378.63	-1.67

As explained above the area based AD in the Forest land sector moved from ENVANIS to a spatially explicit land tracking system. This enabled the production of a consistent land use matrix that determines the land use and conversions with 1 ha accuracy. On the other hand, removals from L-FL decreased significantly with the new system. The reason for this was the change in AD.

Planned Improvement:

The Forest Land is the major category. The removals are based on the increment data while emissions are on the harvest. An improvement plan has been developed for the sector in the framework of the LULUCF project. The plan has three basic scales; short (ST), medium (MT) and long terms (LT).



The planned improvements for Forest Land category are;

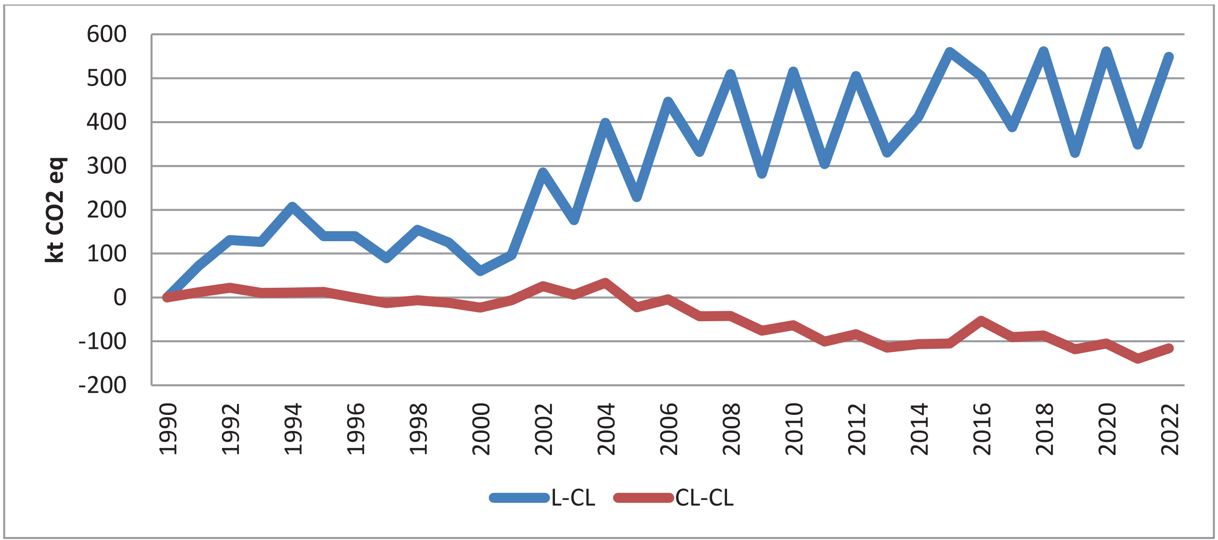
- Re-evaluation of the emission/other factors used for living biomass, DOM, and mineral soils (ST, MT) based on Mediterranean Emission/Other factors Database by the collaboration program of ONF-GDF.
- Estimation of carbon stocks for carbon pools for which emissions are currently not reported, namely deadwood, litter and mineral soil (MT)
- Preparation of input forest data and parameters for some of the existing forest models (e.g. CBM) to be able for running simulations and making projections of forest development under different scenarios (MT, LT)
- Development and establishment of National Forest Inventory (NFI) based on permanent sample plot system (LT)
- Use a higher Tier level in reporting (MT, LT).
- Develop and use allometric equations instead of currently used national BCEF coefficients (MT, LT).
- Preparement of the land use matrix for 2020 or beyond.

6.3. Croplands (4.B)

Source Category Description:

Estimation of emissions and removals from cropland follows the 2006 IPCC guidelines (Volume 4, Ch. 5). Currently, there are two strata for different crops in Türkiye, namely annual and perennial crops. Besides, emissions are estimated due to cultivation of organic soil and direct N_2O emission from N mineralization associated with loss of soil organic matter due to land use change or management of mineral soils.

Figure 6.8 The changes in net emissions and removals in CL-CL and L-CL subcategories



The cropland category is net emissions due to conversions to cropland. The CL-CL subcategory becomes removals in some years and emissions in others. The main reason for this is the rate of conversions between annual and perennial crops. The perennial crops are assumed to have larger C stocks compared to annual crops as explained in the methodology section below. Cropland remaining Cropland and Land converted to Cropland has been reported under this category.

CSC in aboveground, belowground, organic and mineral soil pools have been calculated and reported.

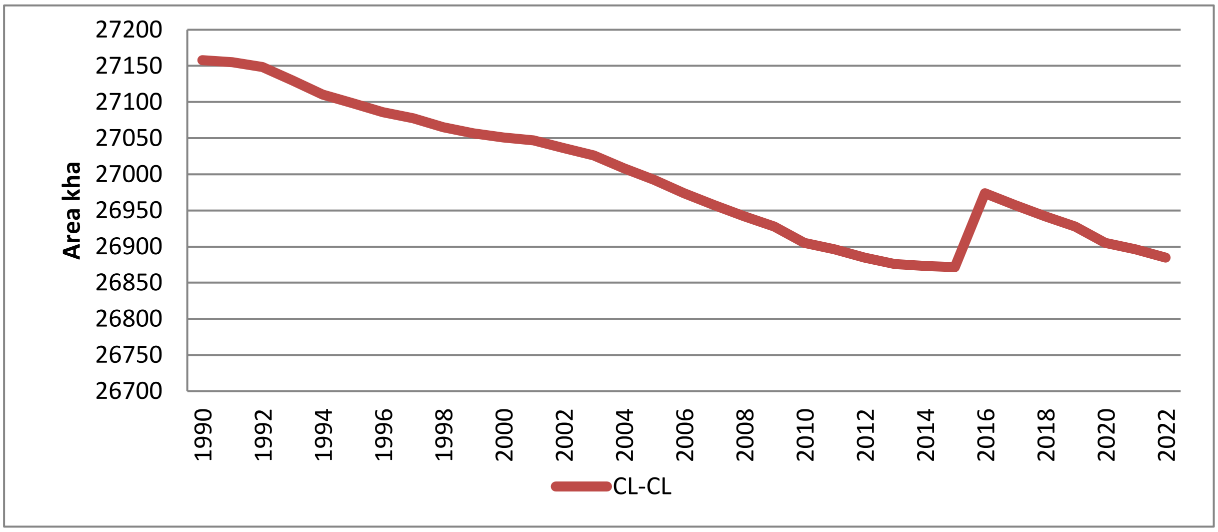
The cropland category was a large emission source but decreased with the change in emission factors (such as carbon content of perennial crops) and activity data.

The Cropland covers all perennial and annual crops in agricultural lands. Orchards and poplars are included in this category.

Information on Land Classification and Activity Data

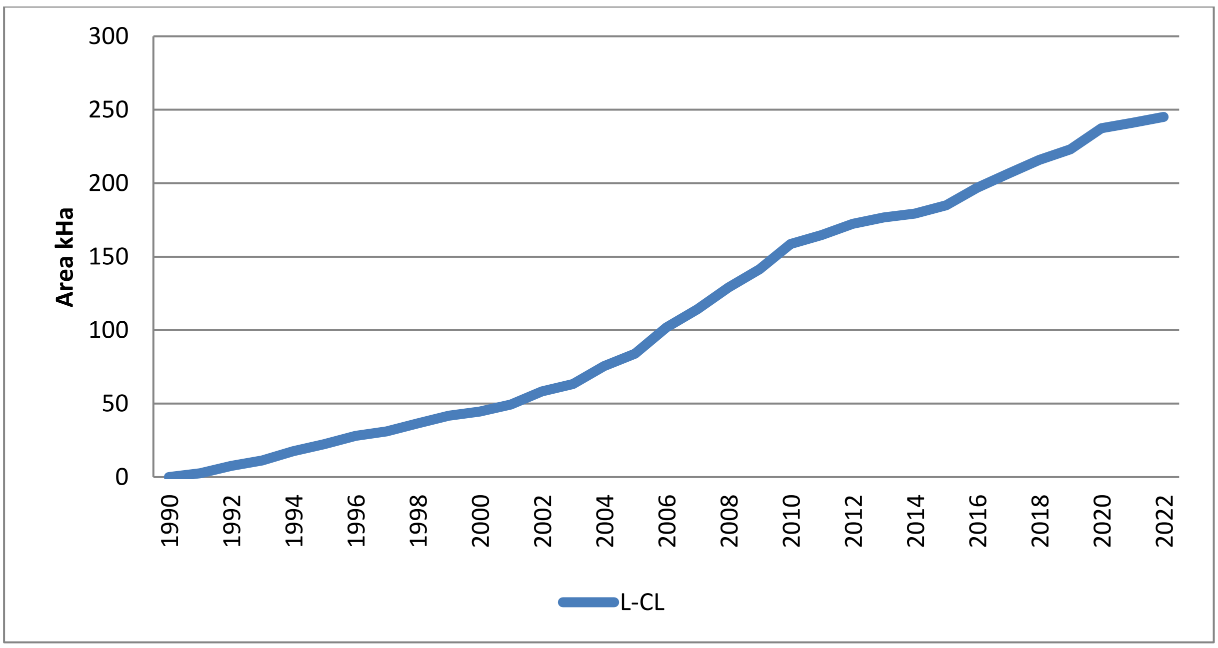
The CL-CL area has been decreasing due to conversions to other land uses during the reporting period, but stabilized around 2010 and began to decrease again, although it increased after 2015 with the addition of lands in L-CL after 2010 (20-year transition period).

Figure 6.9 The change in area of CL-CL



On the other hand, the area of L-CL increases but not with the same ratio as conversions from croplands. Thus the cropland area in total decreases during the reporting period.

Figure 6.10 The change in area of L-CL



Land-use definitions and the classification systems

Activity data for cropland remaining cropland have been subdivided into annual and perennial crops. Cropland category includes all annual and perennial crops including orchards including olives, vineyards and poplar plantations; the change in all carbon pools has been assumed to be not changing for annual and perennial crops. The increase in biomass stocks in a single year is assumed to equal biomass losses from harvest and mortality in that same year. However, CSC have been calculated in case of conversions between annual and perennial croplands.

Methodological Issues:

Annual cropland remaining annual cropland

Above- and below-ground biomass
For annual crops increase in biomass stocks in a single year is assumed to equal biomass losses from harvest and mortality in that same year (IPCC 2006).

Dead organic matter
According to Tier 1 method, there is no need to estimate the carbon stock changes for DOM.

Mineral and organic soils
Currently, there is no specific data on management systems in the country to apply reference carbon stocks and stock change factors. Emissions from organic soil are estimated using the default equation and emission factors.

Since most of Turkey is located in the warm temperate dry climate zone (Chapter 3 Volume_4_AFOLU), calculations for organic soils in the CL-CL category were made using the IPCC default value of 10 tonnes C/ha/year for warm temperate CL in Table 5.6 (Chapter 5 Volume_4_AFOLU)
Reference to 2006 IPCC equations: Vol. 4., Ch. 2: 2.24 / 2.25 / 2.26

Country-specific SOC_{ref} values were developed within the scope of the Organic Carbon Project conducted by the General Directorate of Agricultural Research and Policies (TAGEM) of the Ministry of Agriculture and Forestry. Within the scope of this project, soil maps for 2010-2015 were produced using data collected between 1995 and 2010. In this study, 81 provinces were taken as basis, digital provincial soil maps (1/25.000 scale) were used, geology, land use and topography were taken into consideration in soil sampling and samples were taken from 0-30 cm depths and prepared in accordance with IPCC guidelines.

SOC values according to land uses were calculated based on country-specific SOCref values, IPCC equation 2.25 (T1) and temperate zone coefficients in Table 5.5.

Perennial cropland remaining perennial cropland

Above- and below-ground biomass

At present, the Gain-Loss method has been applied to estimate CSC in biomass pools. The rotation period for perennial crops were assumed according to values used by the inventory of Italy. If perennial crops, such as vineyards, orchards and olive groves can be disaggregated regarding spatially-explicit activity data, then default values for carbon stocks at maturity, rotation periods, biomass accumulation rates etc. for these crops can be calculated from the MediNet Biomass Report (Canaveira et al., 2018). Canaveira P, Manso S, Pellis G, Perugini L, De Angelis P, Neves R, Papale D, Paulino J, Pereira T, Pina A, Pita G, Santos E, Scarascia-Mugnozza G, Domingos T, and Chiti T (2018). Biomass Data on Cropland and Grassland in the Mediterranean Region. Final Report for Action A4 of Project MediNet.
Reference to 2006 IPCC equation: Vol. 4., Ch. 2: 2.7

The perennial plant carbon stock values in Table 27 of the MediNet Biomass Report (Canaveira et al., 2018) in the Medinet project were taken by calculating the weighted average of the perennial crop types in the country according to area statistics of perennial crop types (TURKSTAT Statistics).
6.3. Croplands (4.B) are explained in the Recalculation section.

Since the size of loss due to harvesting is usually not available for perennial woody biomass, the CSC in living biomass has been assumed to be compensated with the harvest of the trees. Hence C gains due to the increment of the perennial trees are neutralized by the loss due to cutting of the trees at 100/rotation period of the total perennial crops area. The rotation period of perennial croplands is assumed to be 20 years, with 13.16 tons C/ha when mature. Thus the increment is 0.66 tons C/ha/yr.

Dead organic matter

According to Tier 1 method the carbon stock changes for DOM has not been estimated. If specific national data on different crop and climate types and management practices or periodic inventories are improved then Gain-Loss or Stock-Difference method, respectively, can be applied.

Mineral and organic soils

Currently, there is no specific data on management systems in the country to apply reference carbon stocks and stock change factors. Tier 1 method can be applied when these data become available.
Emissions from organic soil have been estimated using a default equation and emission factor.
It is explained in Section 6.3 Croplands (Mineral and organic soils).

Reference to 2006 IPCC equations: Vol. 4., Ch. 2: 2.24 / 2.25 / 2.26

Annual cropland converted to perennial cropland

The 2006 IPCC guidelines do not include any specific method for conversions between annual and perennial cropland. As carbon accumulation rates and soil carbon stocks in these two cropland subcategories are different, more accurate estimation of emissions and removals is needed.

Annual CSC in biomass has been estimated using the equation below:

*Annual change in biomass = conversion area for a transition period of 20 years * ΔC_{growth} + annual area of currently converted land * $\Delta C_{conversion}$*

$\Delta C_{conversion} = C_{after} - C_{before}$

C_{after} = carbon stock immediately after conversion (at Tier 1 assume $C_{after} = 0$)

C_{before} = carbon stock of annual crop before conversion (IPCC default value = 5 t C ha^{-1})

ΔC_{growth} = carbon accumulation rate of perennial crops (0.66 t C ha^{-1} yr^{-1})

The biomass loss is accounted only for the year of conversion, thus $\Delta C_{conversion}$ must be multiplied by annual area (i.e. area in the year of conversion).

Reference to 2006 IPCC equations: Vol. 4., Ch. 2: 2.15 / 2.16

The calculation spreadsheet for annual-perennial conversion is as follows;

Table 6.20 Coefficients and CS values used in annual/perennial conversions in cropland category

Ecozones	NAI Y1 ΔC*G* (tC/yr/ha)	Loss Y1 ΔCL (tC/yr/ha)	BAFTER (tC/yr)	BBEFORE (tC/yr	CSC Y1 (tC/ha/yr)	NAI Y2 (tC/ha/yr)
Mediterranean Mountain zone	0.66	0	0	5	-4.34	0.66
Mediterranean coastal zone deciduous and coniferous forest	0.66	0	0	5	-4.34	0.66
East Anatolian steppe	0.66	0	0	5	-4.34	0.66
East Anatolian deciduous forest zone	0.66	0	0	5	-4.34	0.66
Euxine-Colchic deciduous forest	0.66	0	0	5	-4.34	0.66
Central Anatolian steppe	0.66	0	0	5	-4.34	0.66
Aegean Inland deciduous and coniferous forest	0.66	0	0	5	-4.34	0.66
North Anatolian deciduous, coniferous and mixed forest	0.66	0	0	5	-4.34	0.66

As seen from Table CS for annual crops is 5 tC/ha and is lost in the first year of conversion while the planted seedlings grow with 0.66 tC/ha per year for the next 20 years until the land is allocated as CL-CL.

Dead organic matter

According to Tier 1 method, carbon stock changes for DOM are assumed to be not changing.

Mineral and organic soil

According to Tier 2 method country-specific carbon stocks have been used to estimate annual change in organic carbon stocks in mineral soil. Country-specific carbon stocks have been calculated by the TAGEM (General Directorate of Agricultural Research) and used for both cropland subcategories in case of conversion, default equation, assuming a transition period of 20 years has been used. Emissions from organic soil should be estimated using a default equation and emission factors.

It is explained in Section 6.3 Croplands (Mineral and organic soils).

Reference to 2006 IPCC equations: Vol. 4., Ch. 2: 2.24 / 2.25 / 2.26

The below default coefficients have been employed to calculate CSC in mineral soils in case of conversions (between cropland subcategories or LULUCF land use categories) CS for annual and perennial croplands. The SOC of perennial crops has been assumed to be same as SOC_{ref}.

Table 6.20a Coefficients and soil CS values used in annual/perennial conversions in cropland category

Ecozone	SOC ref (tC/ha)	$CS_{annualcrops}$ (tC/ha)	$CS_{perennialcrops}$ (tC/ha)
Mediterranean Mountain zone	46.96	40.22	46.96
Mediterranean coastal zone deciduous and coniferous forest	37.77	29.62	37.77
East Anatolian steppe	47.99	38.90	47.99
East Anatolian deciduous forest zone	41.30	30.44	41.30
Euxine-Colchic deciduous forest	49.66	38.68	49.66
Central Anatolian steppe	40.41	32.14	40.41
Aegean Inland deciduous and coniferous forest	42.53	30.99	42.53
North Anatolian deciduous, coniferous and mixed forest	54.57	34.29	54.57

Perennial cropland converted to annual cropland

Annual CSC in biomass on areas of conversion from perennial cropland to annual cropland has been estimated by the same equation as for the opposite management change with the difference that only annual area of currently converted land is considered here because the gains of the annual crop during land use changes to annual cropland are accounted only once.

The estimation of CSC in biomass has been performed using the equation below:

Annual change in biomass = annual area of currently converted land $*(\Delta C_{conversion} + \Delta C_{growth})$

$\Delta C_{conversion} = C_{after} - C_{before}$

C_{after} = carbon stock immediately after conversion (at Tier 1 assume $C_{after} = 0$)

C_{before} = carbon stock of annual/perennial crop before conversion (13.16 t C ha^{-1})

ΔC_{growth} = carbon accumulation rate of annual/perennial crop (IPCC default value = 5 t C ha^{-1})

Dead organic matter

According to Tier 1 method, carbon stock changes for DOM are assumed to be not changing.

Mineral and organic soil

According to Tier 2 method country-specific carbon stocks have been used to estimate annual change in organic carbon stocks in mineral soil. Country-specific carbon stocks have been calculated by the TAGEM (General Directorate of Agricultural Research) and used for both cropland subcategories in case of conversion, default equation, assuming a transition period of 20 years has been used. Emissions from organic soil should be estimated using a default equation and emission factors.
It is explained in Section 6.3 Croplands (Mineral and organic soils).

Reference to 2006 IPCC equations: Vol. 4., Ch. 2: 2.24 / 2.25 / 2.26

Land converted to cropland

Above- and below-ground biomass

Changes in biomass carbon stocks have been estimated according to Tier 1/Tier 2 method with spatially-explicit activity data. Conversions from all other land uses (e.g. from forest land, grassland etc.) to cropland are likely to occur in the country. The principle of estimating the CSC in biomass in land converted to cropland is the same as described in the subcategories annual cropland converted to perennial and vice versa, depending on conversion to which cropland subcategory happened (i.e. annual or perennial cropland).
Below calculation algorithms have been applied for land conversions to Cropland;

In case of forest land converted to annual and perennial cropland;

Table 6.21 Coefficients and CS values used in L-CL category

For FL-CLannual

Ecozone		CF	ΔCG (tC/yr/ha)	ΔCL (tC/yr/ha)	B_{AFTER} (tC/yr/ha)	B_{BEFORE} (tC/ha)	CSC Y1 (tC/ha/yr)	CSC Y2 (tC/ha/yr)
i.e. Mediterranean Mountain zone	Forest Deciduous	0.48	5.00	0	0	41.97	-36.97	0
	Forest Coniferous	0.51	5.00	0	0	64.80	-59.80	0
	Forest Mixed	0.49	5.00	0	0	52.35	-47.35	0
	Forest Degraded	0.49	5.00	0	0	4.051	0.95	0

For FL-CLperennial

i.e. Mediterranean Mountain zone	Forest Deciduous	0.48	0.66	0	0	41.97	-41.31	0.66
	Forest Coniferous	0.51	0.66	0	0	64.80	-64.14	0.66
	Forest Mixed	0.49	0.66	0	0	52.35	-51.69	0.66
	Forest Degraded	0.49	0.66	0	0	4.05	-3.30	0.66

In case of grassland converted to annual and perennial cropland;

For GL-CLannual

Ecozone		ΔCG (tC/yr/ha)	ΔCL (tC/yr/ha)	B_{AFTER} (tC/yr/ha)	B_{BEFORE} (tC/ha)	CSC Y1 (tC/ha/yr)	CSC Y2 (tC/ha/yr)
i.e. Mediterranean Mountain zone	GL-CLann	5.00	0	0	1.86	3.14	0

For GL-CLannual

i.e. Mediterranean Mountain zone	GL-CLper	0.66	0	0	1.86	-1.2	0.66

In case of wetland (managed/unmanaged) converted to annual and perennial cropland;

For WLmanaged/unmanaged-CLannual

Ecozone		ΔCG (tC/yr/ha)	ΔCL (tC/yr/ha)	B_{AFTER} (tC/yr/ha)	B_{BEFORE} (tC/ha)	CSC Y1 (tC/ha/yr)	CSC Y2 (tC/ha/yr)
i.e. Mediterranean Mountain zone	WLman-CLann	5.00	0	0	1.86	3.14	0
i.e. Mediterranean Mountain zone	WLunman-CLann	5.00	0	0	1.86	3.14	0

For WLmanaged/unmanaged-CLperennial

i.e. Mediterranean Mountain zone	WLman-CLper	0.66	0	0	1.86	-1.2	0.66
i.e. Mediterranean Mountain zone	WLunman-CLper	0.66	0	0	1.86	-1.2	0.66

In case of settlement converted to annual and perennial cropland;

For SL-CLannual

Ecozone		**ΔCG (tC/yr/ha)**	**ΔCL (tC/yr/ha)**	**B_{AFTER} (tC/yr/ha)**	**B_{BEFORE} (tC/ha)**	**CSC Y1 (tC/ha/yr)**	**CSC Y2 (tC/ha/yr)**
i.e. Mediterranean Mountain zone	SL-CLann	5.00	0	0	5.03	-0.03	0

For SL-CLperennial

i.e. Mediterranean Mountain zone	SL-CLper	0.66	0	0	5.03	-4.37	0.66

In case of other land converted to annual and perennial cropland;

For OL-CLannual

Ecozone		**ΔCG (tC/yr/ha)**	**ΔCL (tC/yr/ha)**	**B_{AFTER} (tC/yr/ha)**	**B_{BEFORE} (tC/ha)**	**CSC Y1 (tC/ha/yr)**	**CSC Y2 (tC/ha/yr)**
i.e. Mediterranean Mountain zone	OL-CLann	5	0	5	0	0	0

For OL-CLperennial

i.e. Mediterranean Mountain zone	OL-CLper	0.66	0	0	0	0.66	0.66

Dead organic matter

A Tier 1 method takes into account the estimation of CSC in dead organic matter only for major conversion categories (e.g. forest land to cropland). It is assumed that all dead organic matter is removed in the year of conversion, so there is no accumulation in land converted to cropland afterwards.

Reference to 2006 IPCC equation: Vol. 4., Ch. 2: 2.23,

Table 6.22 Coefficients and CS values used in L-CL category

For FL-CLannual/perennial

Ecozone		CFlitter	CFdw	CSC LT (tC/ha)	CSC DW (tC/ha)	CSC DOM (tC/ha)
i.e. Mediterranean Mountain zone	Forest Deciduous	0.37	0.50	-3.09	-0.49	-3.58
	Forest Coninferous	0.37	0.50	-7.51	-0.36	-7.87
	Forest Mixed	0.37	0.50	-5.30	-0.42	-5.72
	Forest Degraded	0.37	0.50	0.00	-0.03	-0.03

Mineral and organic soil

The Tier 2 method has been applied here, as country-specific reference carbon stocks were available for all land categories. The general approach, assuming the 20-year transition period after which the soil reaches a new equilibrium, has been used for land use changes to cropland. In case organic soil is subject to this type of land-use change, emissions have been estimated using the default emission factor and method.

Reference to 2006 IPCC equations: Vol. 4., Ch. 2: 2.24 / 2.25 / 2.26

In case of forest land (FL) converted to annual and perennial cropland;

Table 6.23 Coefficients and soil CS values used in L-CL category

Ecozone	Forest Type	C stock Forest land (tC/ha)	SOC ref	C stock Cropland (tC/ha)	CSC Y1 (tC/ha/yr)	NAI Y2 (tC/ha/yr)
FL-CLannual						
Mediterranean Mountain zone	FL-CLann	51.53	46.96	40.22	-0.57	-0.57
Mediterranean coastal zone deciduous and coniferous forest	FL-CLann	46.08	37.77	29.62	-0.82	-0.82
East Anatolian steppe	FL-CLann	48.41	47.99	38.90	-0.48	-0.48
East Anatolian deciduous forest zone	FL-CLann	45.14	41.30	30.44	-0.74	-0.74
Euxine-Colchic deciduous forest	FL-CLann	51.90	49.66	38.68	-0.66	-0.66
Central Anatolian steppe	FL-CLann	49.92	40.41	32.14	-0.89	-0.89
Aegean Inland deciduous and coniferous forest	FL-CLann	50.88	42.53	30.99	-0.99	-0.99
North Anatolian deciduous, coniferous and mixed forest	FL-CLann	55.05	54.57	34.29	-1.04	-1.04
FL-CLperennial						
Mediterranean Mountain zone	FL-CLper	51.53	46.96	46.96	-0.23	-0.23
Mediterranean coastal zone deciduous and coniferous forest	FL-CLper	46.08	37.77	37.77	-0.42	-0.42
East Anatolian steppe	FL-CLper	48.41	47.99	47.99	-0.02	-0.02
East Anatolian deciduous forest zone	FL-CLper	45.14	41.30	41.30	-0.19	-0.19
Euxine-Colchic deciduous forest	FL-CLper	51.90	49.66	49.66	-0.11	-0.11
Central Anatolian steppe	FL-CLper	49.92	40.41	40.41	-0.48	-0.48
Aegean Inland deciduous and coniferous forest	FL-CLper	50.88	42.53	42.53	-0.42	-0.42
North Anatolian deciduous, coniferous and mixed forest	FL-CLper	55.05	54.57	54.57	-0.02	-0.02

In case of grassland (GL) converted to annual and perennial cropland;

Ecozone	SOC ref	C stock Grassland (tC/ha)	C stock Cropland (annual) (tC/ha)	CSC Y1 (tC/ha/yr)	NAI Y2 (tC/ha/yr)
GL-CLannual					
Mediterranean Mountain zone	46.96	42.26	40.22	-0.10	-0.10
Mediterranean coastal zone deciduous and coniferous forest	37.77	33.99	29.62	-0.22	-0.22
East Anatolian steppe	47.99	43.19	38.90	-0.21	-0.21
East Anatolian deciduous forest zone	41.30	37.17	30.44	-0.34	-0.34
Euxine-Colchic deciduous forest	49.66	44.69	38.68	-0.30	-0.30
Central Anatolian steppe	40.41	36.37	32.14	-0.21	-0.21
Aegean Inland deciduous and coniferous forest	42.53	38.28	30.99	-0.36	-0.36
North Anatolian deciduous, coniferous and mixed forest	54.57	49.11	34.29	-0.74	-0.74
GL-CLperennial					
Mediterranean Mountain zone	46.96	42.26	46.96	0.23	0.23
Mediterranean coastal zone deciduous and coniferous forest	37.77	33.99	37.77	0.19	0.19
East Anatolian steppe	47.99	43.19	47.99	0.24	0.24
East Anatolian deciduous forest zone	41.30	37.17	41.30	0.21	0.21
Euxine-Colchic deciduous forest	49.66	44.69	49.66	0.25	0.25
Central Anatolian steppe	40.41	36.37	40.41	0.20	0.20
Aegean Inland deciduous and coniferous forest	42.53	38.28	42.53	0.21	0.21
North Anatolian deciduous, coniferous and mixed forest	54.57	49.11	54.57	0.27	0.27

In case of wetland (WL) (Managed/Unmanaged) converted to annual and perennial cropland;

Parameters/C stock in year (tC/yr/ha)	SOC ref	C stock Wetlands (tC/ha)	C stock Cropland (annual) (tC/ha)	CSC Y1 (tC/ha/yr)	NAI Y2 (tC/ha/yr)
WL-CLannual					
Mediterranean Mountain zone	46.96	42.26	40.22	-0.10	-0.10
Mediterranean coastal zone deciduous and coniferous forest	37.77	33.99	29.62	-0.22	-0.22
East Anatolian steppe	47.99	43.19	38.90	-0.21	-0.21
East Anatolian deciduous forest zone	41.30	37.17	30.44	-0.34	-0.34
Euxine-Colchic deciduous forest	49.66	44.69	38.68	-0.30	-0.30
Central Anatolian steppe	40.41	36.37	32.14	-0.21	-0.21
Aegean Inland deciduous and coniferous forest	42.53	38.28	30.99	-0.36	-0.36
North Anatolian deciduous, coniferous and mixed forest	54.57	49.11	34.29	-0.74	-0.74
WL-CLperennial					
Mediterranean Mountain zone	46.96	42.26	46.96	0.23	0.23
Mediterranean coastal zone deciduous and coniferous forest	37.77	33.99	37.77	0.19	0.19
East Anatolian steppe	47.99	43.19	47.99	0.24	0.24
East Anatolian deciduous forest zone	41.30	37.17	41.30	0.21	0.21
Euxine-Colchic deciduous forest	49.66	44.69	49.66	0.25	0.25
Central Anatolian steppe	40.41	36.37	40.41	0.20	0.20
Aegean Inland deciduous and coniferous forest	42.53	38.28	42.53	0.21	0.21
North Anatolian deciduous, coniferous and mixed forest	54.57	49.11	54.57	0.27	0.27

In case of settlements (SL) converted to annual and perennial cropland;

Ecozones	C stock Settlements (tC/ha)	SOC ref	C stock Cropland (annual) (tC/ha)	CSC Y1 (tC/ha/yr)	NAI Y2 (tC/ha/yr)
SL-CLannual					
Mediterranean Mountain zone	20.14	46.96	40.22	1.00	1.00
Mediterranean coastal zone deciduous and coniferous forest	20.14	37.77	29.62	0.47	0.47
East Anatolian steppe	20.14	47.99	38.90	0.94	0.94
East Anatolian deciduous forest zone	20.14	41.30	30.44	0.51	0.51
Euxine-Colchic deciduous forest	20.14	49.66	38.68	0.93	0.93
Central Anatolian steppe	20.14	40.41	32.14	0.60	0.60
Aegean Inland deciduous and coniferous forest	20.14	42.53	30.99	0.54	0.54
North Anatolian deciduous, coniferous and mixed forest	20.14	54.57	34.29	0.71	0.71
SL-CLperennial					
Mediterranean Mountain zone	20.14	46.96	46.96	1.34	1.34
Mediterranean coastal zone deciduous and coniferous forest	20.14	37.77	37.77	0.88	0.88
East Anatolian steppe	20.14	47.99	47.99	1.39	1.39
East Anatolian deciduous forest zone	20.14	41.30	41.30	1.06	1.06
Euxine-Colchic deciduous forest	20.14	49.66	49.66	1.48	1.48
Central Anatolian steppe	20.14	40.41	40.41	1.01	1.01
Aegean Inland deciduous and coniferous forest	20.14	42.53	42.53	1.12	1.12
North Anatolian deciduous, coniferous and mixed forest	20.14	54.57	54.57	1.72	1.72

In case of otherland (OL) converted to annual and perennial cropland;

Ecozones	C stock Otherland (tC/ha)	SOC ref	C stock Cropland (annual) (tC/ha)	CSC Y1 (tC/ha/yr)	NAI Y2 (tC/ha/yr)
OL-CLannual					
Mediterranean Mountain zone	12.78	46.96	40.22	1.37	1.37
Mediterranean coastal zone deciduous and coniferous forest	12.78	37.77	29.62	0.84	0.84
East Anatolian steppe	12.78	47.99	38.90	1.31	1.31
East Anatolian deciduous forest zone	12.78	41.30	30.44	0.88	0.88
Euxine-Colchic deciduous forest	12.78	49.66	38.68	1.30	1.30
Central Anatolian steppe	12.78	40.41	32.14	0.97	0.97
Aegean Inland deciduous and coniferous forest	12.78	42.53	30.99	0.91	0.91
North Anatolian deciduous, coniferous and mixed forest	12.78	54.57	34.29	1.08	1.08
OL-CLperennial					
Mediterranean Mountain zone	12.78	46.96	46.96	1.71	1.71
Mediterranean coastal zone deciduous and coniferous forest	12.78	37.77	37.77	1.25	1.25
East Anatolian steppe	12.78	47.99	47.99	1.76	1.76
East Anatolian deciduous forest zone	12.78	41.30	41.30	1.43	1.43
Euxine-Colchic deciduous forest	12.78	49.66	49.66	1.84	1.84
Central Anatolian steppe	12.78	40.41	40.41	1.38	1.38
Aegean Inland deciduous and coniferous forest	12.78	42.53	42.53	1.49	1.49
North Anatolian deciduous, coniferous and mixed forest	12.78	54.57	54.57	2.09	2.09

Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

Table 6.24 Uncertainty summary table for Cropland subcategories

	BY (1990)	LRY (2022)
Cropland Remaining Cropland		
4B1 – CL-CL	7.3%	9.9%
Net C stock change in Living Biomass (ΔCC)	0.0%	12.6%
Net C stock change in DOM (ΔCC)	NO	NA
Net C stock change in SOM (ΔCC)	7.3%	15.3%
Land Converted to Cropland		
4B2 – L-CL	0%	47%
ΔCC in Living Biomass	NO	46%
Annual Loss Living Biomass (ΔCL)	NO	NA
Annual Gain Living Biomass (ΔCG)	NO	NA
Net C stock change in Dead Organic Matter (ΔCC)	NO	42%
Net C stock change in SOM (ΔCC)	NO	64%

Source-Specific QA/QC and Verification:

The QA/QA procedure has been realized in the framework of a plan developed and carried out by TurkStat the national inventory agency. The sector specific QA/QC has been realized during the LULUCF project activities mentioned above. The calculation procedures have been checked and discussed with the LULUCF experts in and out of the agencies.

Recalculation:

The weighted average of the perennial crop' carbon stock values found in Figure 6.21 of the MediNet Biomass Report of the Medinet project (Canaveira et al., 2018) according to the land statistics of the perennial plant crop types in the country (TURKSTAT Statistics) was calculated and used as 13.16 tons of C per hectar. Based on the 20-year rotation period, an annual increase was taken as 0.66 tons. The calculations are also reflected in all categories related to CL perennial.

Figure 6.11 Proposed Default Carbon Stocks at Maturity

	Above Ground Biomass AGB [1]			Below Ground Biomass BGB			Total	Maturity cycle [2]
	tDM/ha	%C	$tC.ha^{-1}$	$tDM.ha^{-1}$	%C	$tC.ha^{-1}$	$tC.ha^{-1}$	years
Olive Trees	19.4	47%	**9.1**	5.8	45%	**2.6**	**11.7**	20
Vineyards	11.5	48%	**5.5**	9.7	45%	**4.4**	**9.9**	20
Fruit Trees	18.5	46%	**8.5**	12.8	45%	**5.8**	**14.3**	20
Shrublands	15.5	50%	**7.8**	22.0	50%	**11.0**	**18.8**	20

Notes: (1) "*Above Ground Biomass*" refers to biomass after pruning, which corresponds, in Mediterranean conditions, to the carbon stocks in the winter; (2) "*Maturity Cycle*" refers to the time needed for biomass to reach a stable level and not the normal replanting cycles of different crops.

In the CL category, which was mentioned in the methodology section and recalculated upon the recommendation of ERT, the effect of recalculation can be seen in the Table 6.25.

Table 6.25 Changes by the recalculation on Cropland category

Year	Old Values (ktonnes CO_2)	Recalculated Values (ktonnes CO_2)	Changes(%)
1990	0.69	0.69	0.00
1991	84.45	84.42	0.04
1992	152.69	153.00	-0.20
1993	136.89	137.83	-0.69
1994	216.95	218.32	-0.63
1995	150.24	152.32	-1.38
1996	137.37	139.74	-1.73
1997	73.35	76.22	-3.91
1998	145.16	148.11	-2.03
1999	109.21	112.52	-3.03
2000	33.42	37.41	-11.92
2001	86.22	90.26	-4.68
2002	306.44	311.05	-1.50
2003	175.64	181.82	-3.52
2004	425.20	431.63	-1.51
2005	197.72	206.42	-4.40
2006	431.53	442.05	-2.44
2007	277.06	288.67	-4.19
2008	454.00	467.45	-2.96
2009	191.66	206.62	-7.80
2010	435.48	451.45	-3.67
2011	186.10	203.60	-9.40
2012	405.08	421.60	-4.08
2013	197.49	215.75	-9.25
2014	287.37	305.44	-6.29
2015	436.72	454.45	-4.06
2016	322.37	451.46	-40.04
2017	346.26	297.19	14.17
2018	329.39	474.53	-44.06
2019	357.25	211.89	40.69
2020	370.51	456.11	-23.10
2021	362.38	209.13	42.29

Planned Improvement:

The planned improvements for Cropland category are;

- Increase from Tier 1 to Tier 2 method in estimating the carbon stock change in living biomass in Land converted to cropland (MT)
- Collection, sampling and/or modelling of carbon stocks in mineral soil at a larger spatial scale (e.g. consider potential use of National Geospatial Soil Fertility and Soil Organic Carbon Information System) (MT)
- Data collection about management systems (land use, tillage, input) for Cropland remaining cropland, also through use of existing generalised maps of dominant crops in Türkiye (MT)

6.4. Grassland (4.C)

Source Category Description:

Grasslands are all lands with non woody vegetation subject to grazing. CSC in grasslands is assumed to be not changing if management is not changed. Actually, there are grassland rehabilitation projects implemented in the country but conservatively we assumed no change in biomass. We plan to report these projects as the grassland monitoring system becomes available. Emissions from organic soils are reported assuming that all grasslands are managed. Default EFs are used in this procedure but the AD is disaggregated for climate types.

Figure 6.12 The change in net emissions in Grassland category

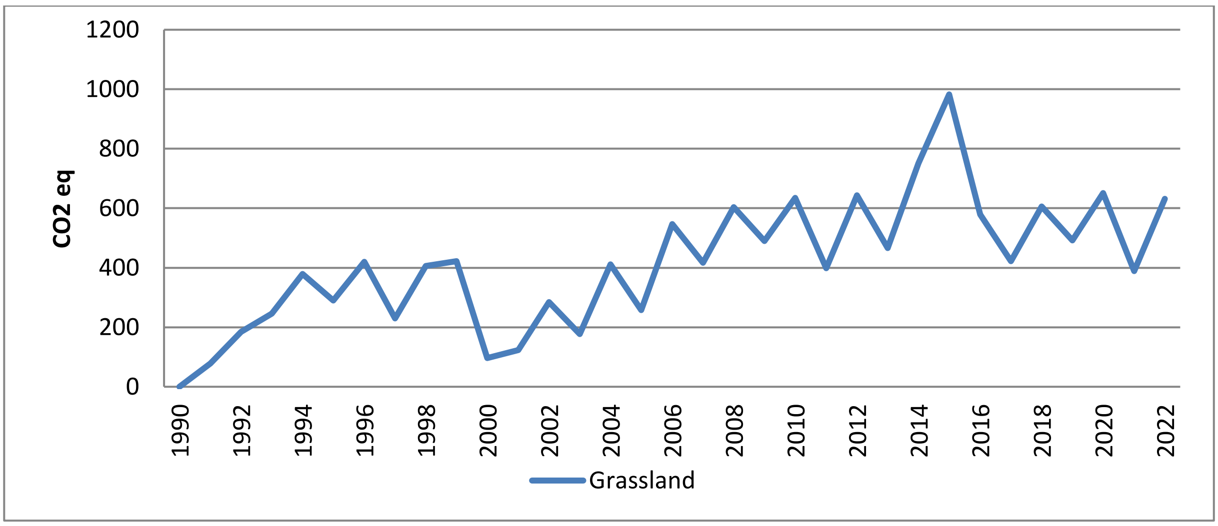


Figure 6.13 The change in area of GL-GL

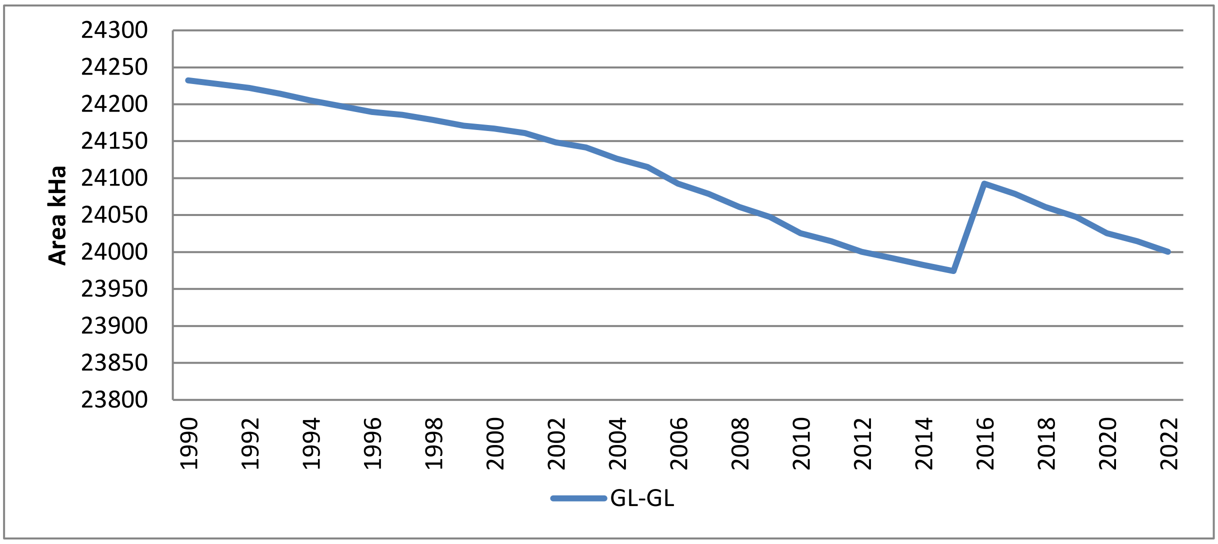
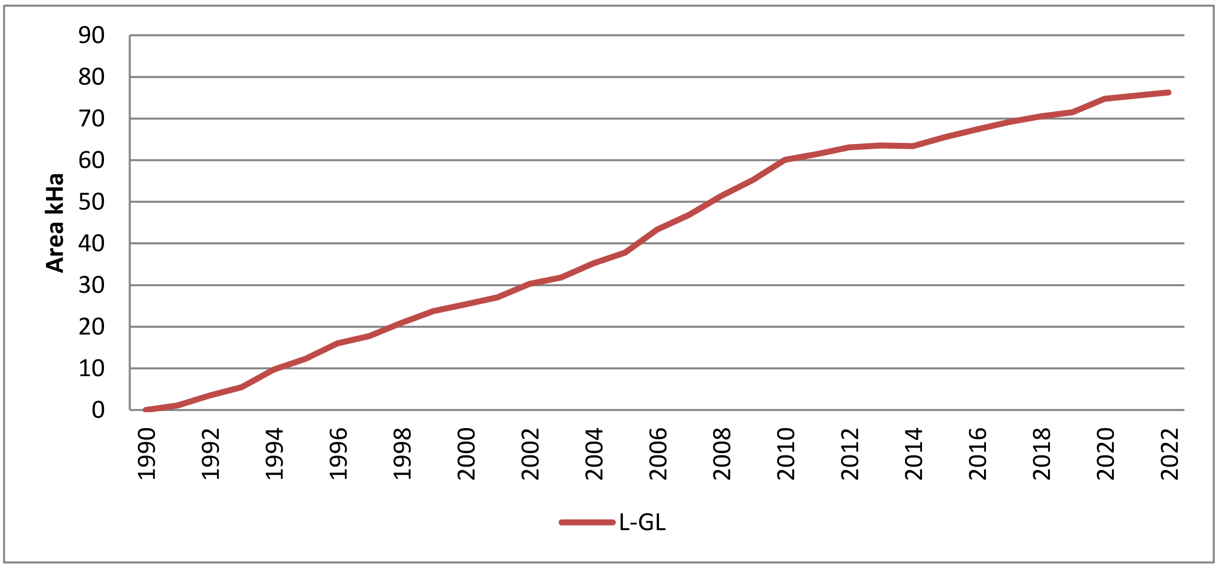


Figure 6.14 The change in area of L-GL



Methodological Issues:

Grassland remaining grassland (GL-GL)

All carbon pools in GL-GL are assumed to be not changing and thus reported as NO except emissions from organic soils. A 3.01 k ha of organic soils have been reported in GL-GL subcategory. This caused a 0.03 k t CO_2 eq. of emissions every year during the reporting period. The management in these areas is not known exactly but is considered as managed to be conservative.
Since the majority of Turkey is located in the warm temperate dry climate zone (Chapter 3 Volume_4_AFOLU), calculations for organic soils in the GL-GL category were made using the IPCC default value of 2.5 (ton C /ha/year) for warm temperate GL in Chapter 6 Volume_4_AFOLU Table 6.3.

Land converted to grassland (GL-GL)

Above- and below-ground biomass

Table 6.26.a Coefficients and living biomass CS values for L-GL subcategories

Ecozones	Forest type	NAI Y1 ΔCG (tC/yr/ha)	Loss Y1 ΔCL (tC/yr/ha)	BAFTER (tC/yr/ha)	BBEFORE (tC/yr/ha)	CSC Y1 (tC/ha/yr)
Forest land converted to Grassland						
i.e. Mediterranean Mountain zone	Forest Deciduous	1.86	0	0	41.97	-40.11
	Forest Coniferous	1.86	0	0	64.80	-62.94
	Forest Mixed	1.86	0	0	52.35	-50.49
	Forest Degraded	1.86	0	0	4.05	-2.19
Cropland (annual) converted to Grassland						
	$Cropland_{annual}$	1.86	0	0	5	-3.14
Cropland (perennial) converted to Grassland						
	$Cropland_{perennial}$	1.86	0	0	13.16	-11.3
Wetland converted to Grassland						
	Grassland	1.86	0	0	1.86	0.00
Settlements converted to Grassland						
	Settlements	1.86	0	0	5.03	-3.17
Otherland converted to Grassland						
	Other land	1.86	0	0	0	1.86

Dead organic matter

CSC converted to wetlands for forest lands are calculated based on the below coefficients and EF. The CSC for other conversions are assumed to be not occurring.

Table 6.26.b Coefficients and DOM CS values for L-GL subcategories

Ecozones	Forest type	CF litter	CF Dead Wood	CSC LT (tC/ha/yr)	CSC DW (tC/ha/yr)	CSC DOM (tC/ha/yr)
Forest land converted to Grassland						
i.e. Mediterranean Mountain zone	Forest Deciduous	0.37	0.50	-3.09	-0.49	-3.58
	Forest Coniferous	0.37	0.50	-7.51	-0.36	-7.87
	Forest Mixed	0.37	0.50	-5.30	-0.42	-5.72
	Forest Degraded	0.37	0.50	0.00	-0.03	-0.03

Mineral and organic soil

The CSC in mineral soils have been calculated based on national stock values determined by General Directorate of Agricultural Research. The default conversion duration of 20 years has been applied.

SOC values by land use were calculated from country-specific SOC_{ref} values using IPCC equation 2.25 (T1) and temperate zone coefficients in Table 5.5.

Table 6.27 Coefficients and soil CS values for L-GL subcategories

Ecozone	SOC ref	C stock Grassland (tC/ha)	Forest land C stock (tC/ha)	Cropland (Annual) C stock (tC/ha)	Cropland (perennial) C stock (tC/ha)	Wetland C stock (tC/ha)	Settl. C stock (tC/ha)	Otherl. C stock (tC/ha)
Mediterranean Mountain zone	46.96	42.26	51.53	40.22	46.96	42.26	20.14	12.78
Mediterranean coastal zone deciduous and coniferous forest	37.77	33.99	46.08	29.62	37.77	33.99	20.14	12.78
East Anatolian steppe	47.99	43.19	48.41	38.90	47.99	43.19	20.14	12.78
East Anatolian deciduous forest zone	41.30	37.17	45.14	30.44	41.30	37.17	20.14	12.78
Euxine-Colchic deciduous forest	49.66	44.69	51.90	38.68	49.66	44.69	20.14	12.78
Central Anatolian steppe	40.41	36.37	49.92	32.14	40.41	36.37	20.14	12.78
Aegean Inland deciduous and coniferous forest	42.53	38.28	50.88	30.99	42.53	38.28	20.14	12.78
North Anatolian deciduous, coniferous and mixed forest	54.57	49.11	55.05	34.29	54.57	49.11	20.14	12.78

Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

Table 6.28 Uncertainty summary table for Grassland subcategories

	BY (1990)	LRY (2022)
Grassland Remaining Grassland		
4C1 – GL-GL	0	0
ΔCC in Living Biomass	NO	NA
Annual Loss Living Biomass (ΔCL)	NO	NA
Annual Gain Living Biomass (ΔCG)	NO	NA
Net C stock change in DOM (ΔCC)	NO	NA
Net C stock change in SOM (ΔCC)	0.00	NA
Land Converted to Grassland		
4C2 – L-GL	0%	149%
ΔCC in Living Biomass	NO	32%
Annual Loss Living Biomass (ΔCL)	NO	NA
Annual Gain Living Biomass (ΔCG)	NO	NA
Net C stock change in DOM (ΔCC)	NO	190%
Net C stock change in SOM (ΔCC)	NO	149%

Source-Specific QA/QC and Verification:

The Qa/Qc procedure has been realized in the framework of a plan developed and carried out by TurkStat the national inventory agency. The sector specific Qa/Qc has been realized during the LULUCF project activities mentioned above. The calculation procedures have been checked and discussed with the LULUCF experts in and out of the agencies.

Recalculation:

It is explained in Section 6.3 Croplands (4.B) Recalculation.

In the GL category, which was mentioned in the methodology section and recalculated upon the recommendation of ERT, the effect of recalculation was -6.4% on average.

Planned Improvement:

The planned improvements for Grassland category are;

- Re-evaluation of the estimation of emissions due to drainage of organic soil (MT)
- Check for the size of emission factors for the subcategory Land converted to grassland (MT)
- Verification of assumptions by surveying national research studies and papers (ST, MT)
- Data collection about management systems (land use, management, input) for Grassland remaining grassland (MT, LT)
- Estimation of carbon stock changes in mineral soil for Grassland remaining grassland, using a default method (applying SOCREF and stock change factors) (MT)
- Modelling of carbon stocks in mineral soil at a larger spatial scale (e.g. considering potential use of National Geospatial Soil Fertility and Soil Organic Carbon Information System) (MT, LT)

6.5. Wetlands (4.D)

Source Category Description:

Emissions/removals from wetlands remaining wetlands are currently assumed to be not occurring. Two subcategories are currently included under the wetlands remaining wetlands in the CRT table 4.D of Türkiye, namely peat extraction remaining peat extraction and flooded land remaining flooded land.

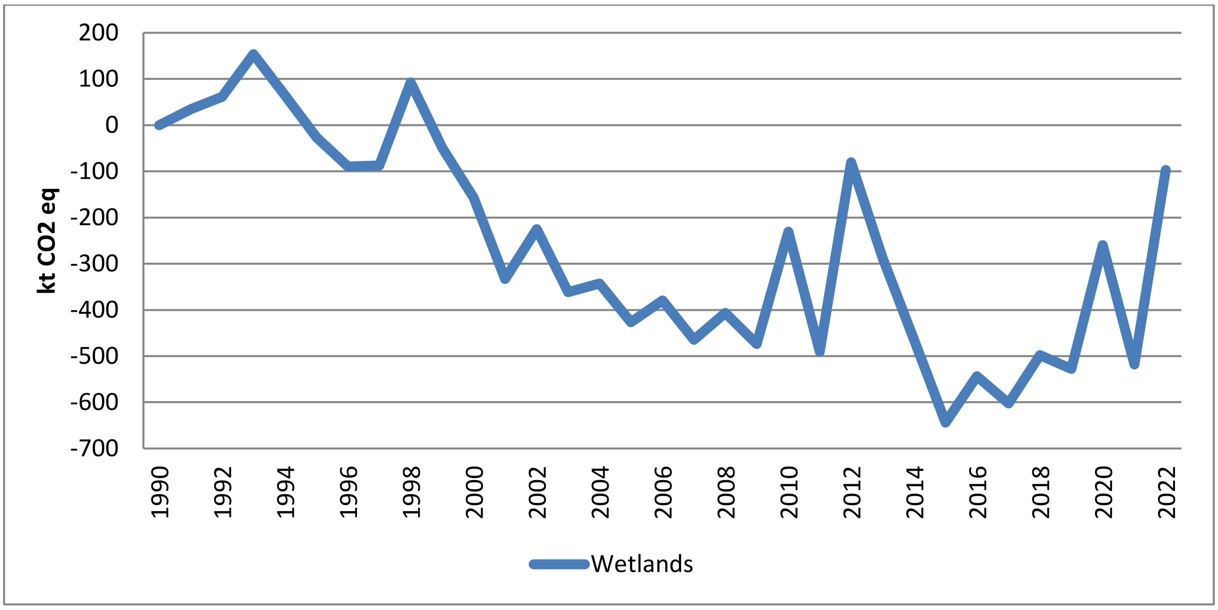
All carbon pools in WL-WL, except peat extraction, are assumed to be unchanged, and thus reported as NO. Information is given in Tables 6.29 and 6.30.

4.D.2 Carbon stock change estimations within the scope of Land Converted to Wetland; 4.D.2.a. Land Converted to Land for Peat Extraction Purposes, 4.D.2.b. It is estimated as Land Converted Under Water. Since the biomass and soil organic carbon emission coefficients that used in grassland areas are the same as the biomass and soil organic carbon emission coefficients that used for wetlands, it was assumed that there was no gain or loss. Therefore it is reported as NO. With the biomass and soil organic carbon emission coefficients are used for wetlands, the gain for cropland is considered to be relatively low.It is reported as NE "Decision 18/CMA.1, Annex, para. 32". Because it is assumed that the loss in CL-WL transformations is not significant.

FL-OWL, CL-OWL, GL-OWL, SL-OWL and OL-OWL conversions are reported in the CRT under 4.D.2.c Land Converted to Other Wetlands.

There is no distinctions are made between the AD of peatlands from which peat is extracted and converted lands. Therefore peat extraction (2006 IPCC Guidelines, vol. 4, ch. 7.2.2, p. 7.17), reported as 4.D.2.1 “IE”.

Figure 6.15 The emissions/removals from wetlands category



As seen from the figure above the emissions in L-WL were not stable. In the years 1993, 2013 and 2022 the emissions peaked. The driver of the fluctuations in emissions was caused by emissions from living biomass pools due to land conversions for the dam building.

Estimation of emissions and removals from wetlands follows the 2006 IPCC guidelines (Volume 4, Ch. 7) and 2013 Wetlands Supplement. Wetlands include any land that is covered or saturated by water for all or part of the year, and that does not fall into the Forest Land, Cropland, or Grassland categories (IPCC 2006). In wetlands category emissions are estimated only for managed wetlands due to human activity, such as drainage, rewetting, dam construction etc.

Information on Land Classification and Activity Data

The wetland managed until 2015 has steadily increased, then decreased and increased again.

Figure 6.16 a The change in area of managed wetlands

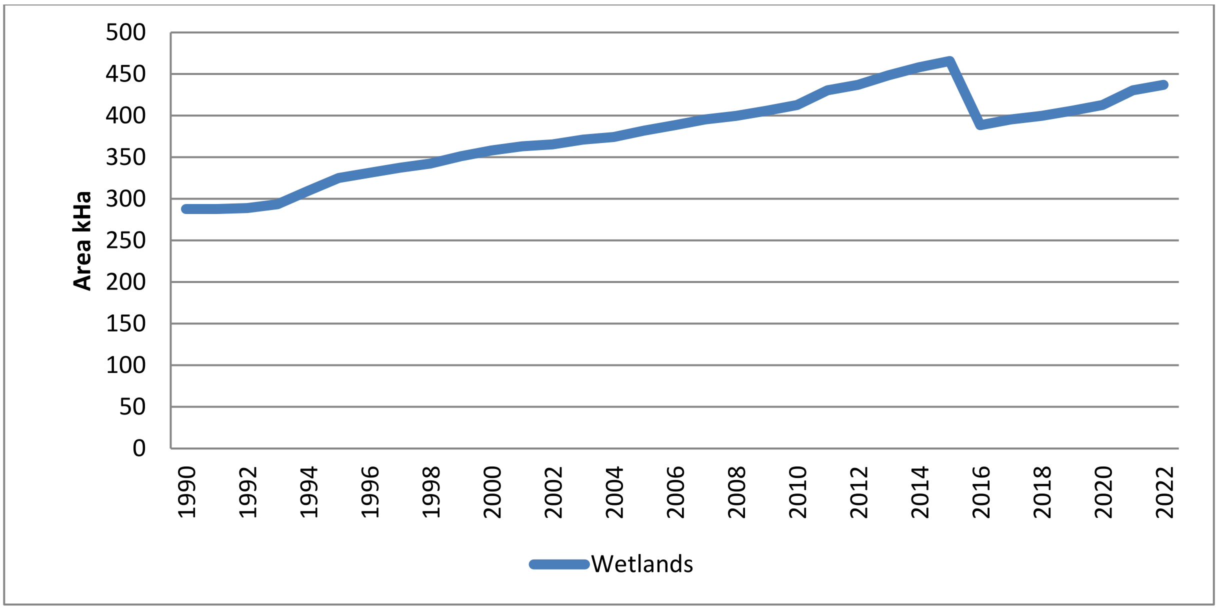
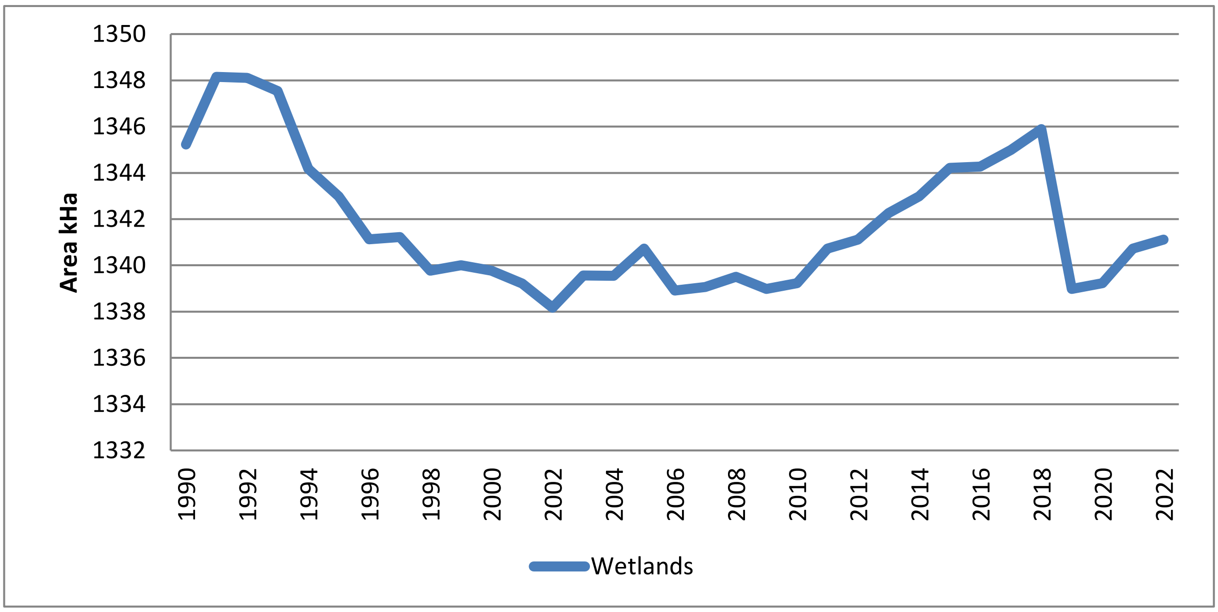


Figure 6.16 b The change in area of unmanaged wetlands



Land-use definitions and the classification systems

All human made reservoirs are included in the managed wetlands category while natural water bodies are in the unmanaged wetlands subcategory.

Methodological Issues:

Wetland remaining wetland (WL-WL)

All carbon pools in WL-WL except peat extraction are assumed to be not changing and thus reported as NO. The activity data used in peat extraction is based on permitted area for extraction by the ministry and depth. We assumed that all permitted area has been subject to production. The on and off site emissions have been estimated at Tier 1 level with default EFs (IPCC Vol. Chapter 7. Table 7.4, 7.5, Temperate zone, nutrient poor).
Reference to 2006 IPCC equations: Vol. 4., Ch. 7: 7.2 / 7.3 /7.4 /7.5

Land converted to wetland (L-WL)

Above- and below-ground biomass

Table 6.29 Coefficients and living biomass CS values for L-WL subcategories

Ecozones	Forest type	NAI Y1 ΔCG (tC/yr/ha)	Loss Y1 ΔCL (tC/yr/ha)	BAFTER (tC/yr/ha)	BBEFORE (tC/yr/ha)	CSC Y1 (tC/ha/yr)
Forest land converted to Wetland						
i.e. Mediterranean Mountain zone	Forest Deciduous	1.86	0	0	41.97	-40.11
	Forest Coniferous	1.86	0	0	64.80	-62.94
	Forest Mixed	1.86	0	0	52.35	-50.49
	Forest Degraded	1.86	0	0	4.05	-2.19
Cropland (annual) converted to Wetland						
	$Cropland_{annual}$	1.86	0	0	5	-3.14
Cropland (perennial) converted to Wetland						
		1.86	0	0	13.16	-11.3
Grassland converted to Wetland						
		0.00	0	1.86	1.86	0.00
Settlements converted to Wetland						
		1.86	0	0	5.03	-3.17
Otherland converted to Wetland						
		1.86	0	0	0	1.86

Dead organic matter

CSC converted to wetlands for forest lands are calculated based on the below coefficients and EF. The CSC for other conversions are assumed to be not occurring. It is assumed that there is no DOM in non-Forestland.

Table 6.30 Coefficients and DOM CS values for L-WL subcategories

Ecozones	Forest type	CF litter	CF Dead Wood	CSC LT (tC/ha/yr)	CSC DW (tC/ha/yr)	CSC DOM (tC/ha/yr)
Forest land converted to Wetland						
i.e. Mediterranean Mountain zone	Forest Deciduous	0.37	0.50	-3.09	-0.49	-3.58
	Forest Coniferous	0.37	0.50	-7.51	-0.36	-7.87
	Forest Mixed	0.37	0.50	-5.30	-0.42	-5.72
	Forest Degraded	0.37	0.50	0.00	-0.03	-0.03

Mineral and organic soil

The CSC in mineral soils have been calculated based on national stock values determined by General Directorate of Agricultural Research. The default conversion duration of 20 years has been applied.

It is explained in Section 6.3 Croplands (Mineral and organic soils).

Table 6.31 Coefficients and soil CS values for L-WL subcategories

Ecozone	SOC ref	C stock Wetlands (tC/ha)	Forest land C stock (tC/ha)	Cropland (Annual) C stock (tC/ha)	Cropland (perennial) C stock (tC/ha)	Grassland C stock (tC/ha)	Settl. C stock (tC/ha)	Otherl. C stock (tC/ha)
Mediterranean Mountain zone	46.96	42.26	51.53	40.22	46.96	42.26	20.14	12.78
Mediterranean coastal zone deciduous and coniferous forest	37.77	33.99	46.08	29.62	37.77	33.99	20.14	12.78
East Anatolian steppe	47.99	43.19	48.41	38.90	47.99	43.19	20.14	12.78
East Anatolian deciduous forest zone	41.30	37.17	45.14	30.44	41.30	37.17	20.14	12.78
Euxine-Colchic deciduous forest	49.66	44.69	51.90	38.68	49.66	44.69	20.14	12.78
Central Anatolian steppe	40.41	36.37	49.92	32.14	40.41	36.37	20.14	12.78
Aegean Inland deciduous and coniferous forest	42.53	38.28	50.88	30.99	42.53	38.28	20.14	12.78
North Anatolian deciduous, coniferous and mixed forest	54.57	49.11	55.05	34.29	54.57	49.11	20.14	12.78

Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3. The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

Table 6.32 Uncertainty summary table for Wetland subcategories

	BY (1990)	LRY (2022)
Wetland Remaining Wetland		
4D1 – WL-WL	0%	0
ΔCC in Living Biomass	NO	NA
Annual Loss Living Biomass (ΔCL)	NO	NA
Annual Gain Living Biomass (ΔCG)	NO	NA
Net C stock change in DOM (ΔCC)	NO	NA
Net C stock change in SOM (ΔCC)	NO	NA
Land Converted to Wetland		
4D2 – L-WL	0%	86%
ΔCC in Living Biomass	NO	33%
Annual Loss Living Biomass (ΔCL)	NO	NA
Annual Gain Living Biomass (ΔCG)	NO	NA
Net C stock change in DOM (ΔCC)	NO	195%
Net C stock change in SOM (ΔCC)	NO	183%

Source-Specific QA/QC and Verification:

The QA/QC procedure has been realized in the framework of a plan developed and carried out by TurkStat the national inventory agency. The sector specific QA/QC has been realized during the LULUCF project activities mentioned above. The calculation procedures have been checked and discussed with the LULUCF experts in and out of the agencies.

Recalculation:

It is explained in Section 6.3 Croplands (4.B) Recalculation.

There has been no reprogramming in this category, but upon ERT's recommendation, unmanaged wetlands are reported as areas only.

Table 6.33 Changes by the recalculation of Lands Converted to Wetlands subcategory

Year	Old Values (ktonnes CO_2)	Recalculated Values (ktonnes CO_2)	Changes (%)
1990	NO, NE	NO, NE, IE	NO, NE, IE
1991	43.9	34.70	26.51
1992	90.38	61.56	46.82
1993	246.15	153.59	60.26
1994	219.73	64.91	238.51
1995	156.37	-26.97	-679.79
1996	120.9	-90.12	-234.15
1997	146.45	-88.02	-266.38
1998	367.56	91.81	300.35
1999	260.18	-50.20	-618.29
2000	174.01	-158.54	-209.76
2001	9.8	-334.54	-102.93
2002	146.9	-226.80	-164.77
2003	25.76	-362.60	-107.10
2004	82.5	-343.95	-123.99
2005	26.12	-428.06	-106.10
2006	109.46	-380.97	-128.73
2007	45.37	-466.29	-109.73
2008	132.97	-408.24	-132.57
2009	95.12	-475.98	-119.98
2010	410.43	-233.14	-276.04
2011	169.29	-493.10	-134.33
2012	607.88	-83.56	-827.48
2013	378.54	-289.93	-230.56
2014	170.13	-469.16	-136.26
2015	-24.2	-647.29	-96.26
2016	267.23	-547.13	-148.84
2017	283.98	-605.70	-146.88
2018	218.24	-501.29	-143.54
2019	184.2	-531.05	-134.69
2020	184.57	-263.35	-170.09
2021	225.61	-522.12	-143.21

The effect of reprogramming of WL, which is passed with finance in the methodology section and reprogrammed throughout the ERT 6.48 is given in a table.

Planned Improvement:

The planned improvements for Wetland category are;

- Use of Wetlands Supplement more effectively (ST, MT)
- Review all existing national and international databases related to wetlands (e.g. Ramsar Convention on Wetlands, FAOSTAT, Wetlands International, NGO data etc.) (MT)
- Expert judgment (e.g. by national soil scientist) about different types of managed wetlands that are likely to occur in Türkiye (ST, MT)
- Collection of activity data regarding specific types of managed wetlands (MT)
- Sampling of SOC and estimation of carbon stocks for major soil types of wetlands (MT, LT)

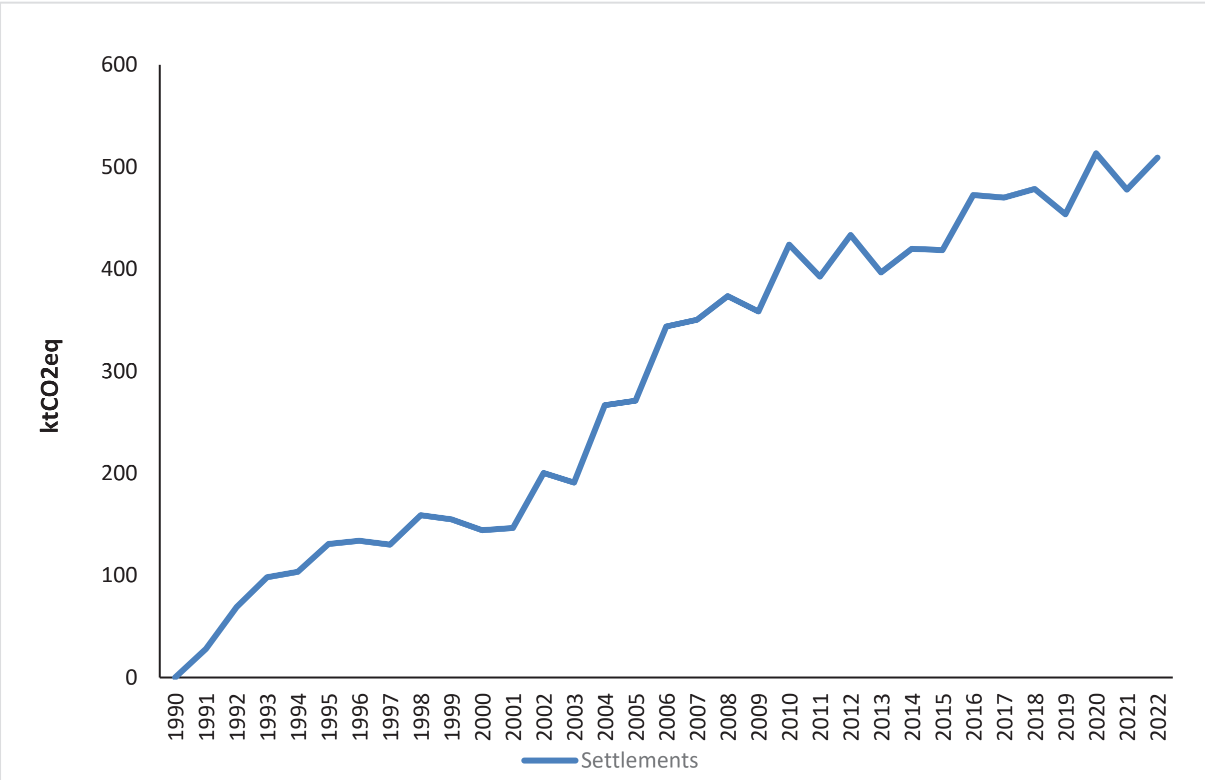
6.6. Settlements (4.E)

Source Category Description:

The carbon stock change in settlements remaining settlements has been estimated to be not changing. Land converted to settlements has led to increased emissions.

The major driver of the emissions has been conversions from other land uses that resulted in loss of carbon.

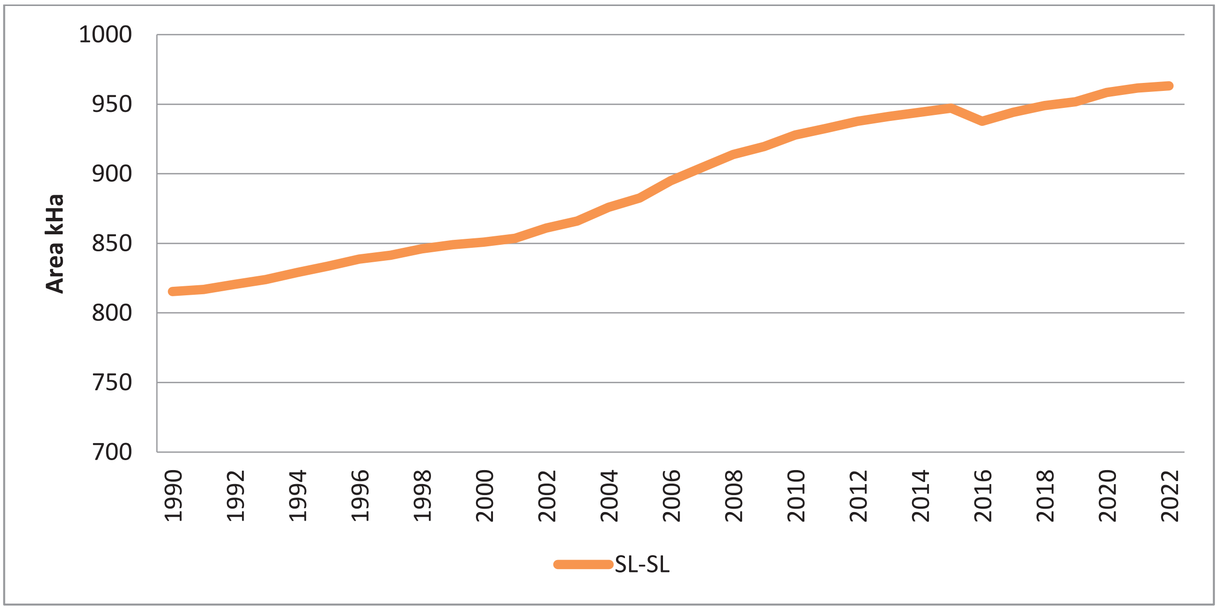
Figure 6.17 The change in net emissions in settlements



Information on Land Classification and Activity Data

The area of settlements is increasing constantly with the conversions mainly from cropland and grassland.

Figure 6.18 The change in area of settlements



Land-use definitions and the classification systems

The emission factors and coefficients for calculating GHG emissions and removals in this category are based on the results of a national research project entitled "*Development of a climate change-ecosystem services software to support sustainable land planning works*" funded by the Scientific and Technical Research Council of Türkiye with the Project Number 112Y096.

The method we used to develop EFs for Settlements category is based on a modelling study while representativeness is weak because the study is conducted only in Istanbul. At least 2-3 similar studies are needed to have higher representativeness. The methodological level is Tier 3 in this estimation because we performed a gridded spatial analysis modelling approach.

Methodological Issues:

Settlements remaining settlements (SL-SL)

All carbon pools in SL-SL are assumed to be not changing thus reported as NO.

The CS values used in other categories have also been used in this category. The forest land living biomass C stocks have been taken from ENVANIS, croplands from both IPCC 2006 and neighbouring countries, grasslands from Serengil et al. (2015). Thus below EFs have been used.
The CS of settlements has been calculated based on the above values in the context of the TUBITAK 112Y096 project. The following methodology has been applied;

- The study area (740 km^2) has been divided into 500*500 meter grids,
- The land uses in each grid have been determined from SPOT6 2013 satellite image with a 1.5*1.5 meter resolution using supervised classification,
- The accuracy check has been performed with 1000 plots with over 90 percent accuracy,
- The land use in each grid has been multiplied by carbon stocks given in Table 6.20.

- The impervious areas in each grid have been grouped under 5 classes that are >20 percent, >40 percent, >60 percent, and >80 percent. The project area has been classified into 4 settlement intensity classes in this way (Table 6.34).

Table 6.34 Total carbon stocks calculated for various settlements intensity classes (Serengil et al., 2015)

Settlement class (SC)	Settlement intensity (% imperviousness)	$\bar{x}$(t C /ha)	σ(t C /ha)	Sample size (#)
1	>20	85.27	74.19	1 145
2	>40	51.87	41.85	697
3	>60	32.04	25.32	438
4	>80	17.26	13.73	258

The weighted average for settlement land cover has been calculated as 25.17 t C/ha in total 20.14 Mg C/ha in biomass, and 5.03 Mg C/ha in soil pools.

The settlement intensity and CS in the study are of the TUBITAK 112Y096 is given in Figure 6.19 and Figure 6.20

Figure 6.19 Impervious areas in the study area (Alibeyköy, Sazlıdere and Kağıthane watersheds in Istanbul)

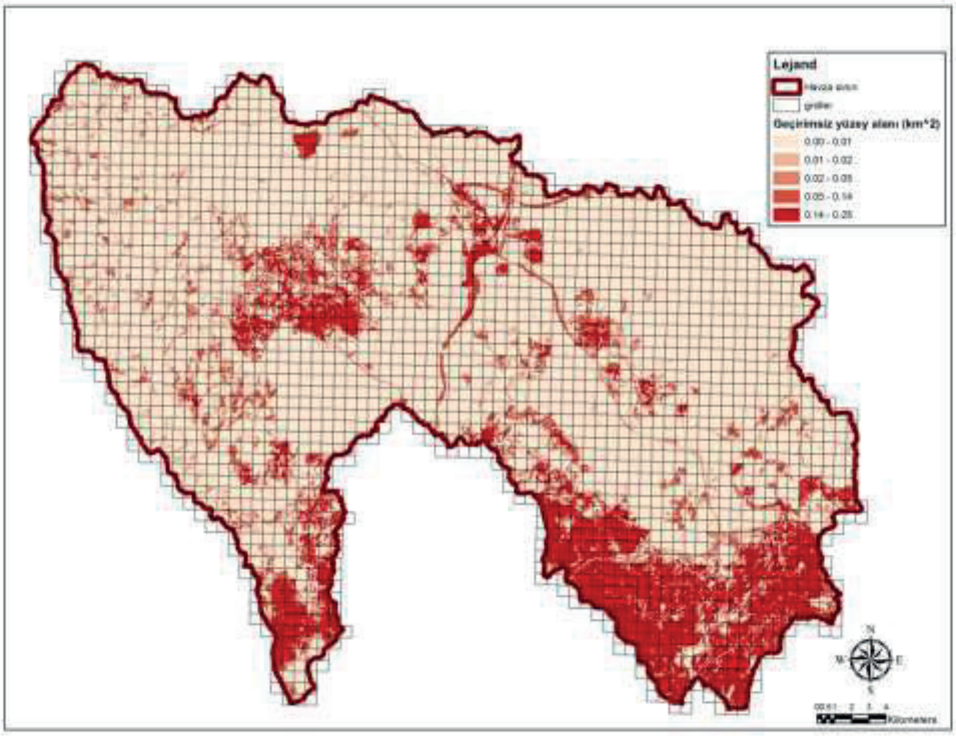
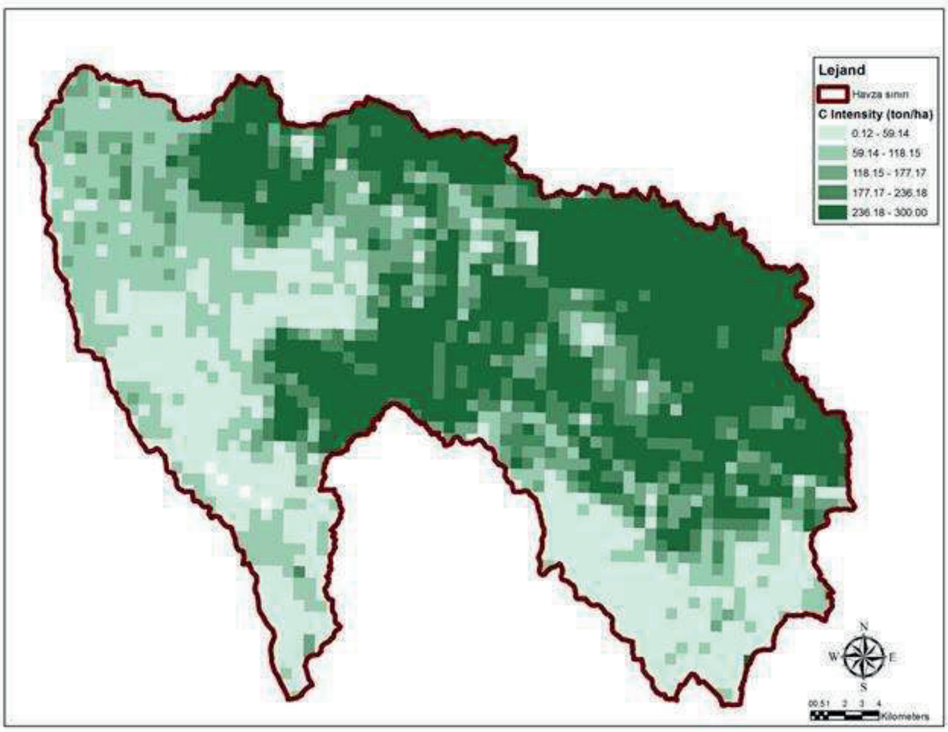


Figure 6.20 Carbon intensity in the study area (Alibeyköy, Sazlıdere and Kağıthane watersheds in Istanbul)



Land converted to settlements (L-SL)

Above- and below-ground biomass

Table 6.35 Coefficients and living biomass CS values for L-SL subcategories

Ecozones	Forest type	NAI Y1 ΔCG (tC/yr/ha)	Loss Y1 ΔCL (tC/yr/ha)	BAFTER (tC/yr/ha)	BBEFORE (tC/yr/ha)	CSC Y1 (tC/ha/yr)
Forest land converted to Settlements						
i.e. Mediterranean Mountain zone	Forest Deciduous	5.03	0	0	41.97	-36.94
	Forest Coniferous	5.03	0	0	64.80	-59.77
	Forest Mixed	5.03	0	0	52.35	-47.32
	Forest Degraded	5.03	0	0	4.05	0.98
Cropland (annual) converted to Settlements						
	$Cropland_{annual}$	5.03	0	0	5	0.03
Cropland (perennial) converted to Settlements						
		5.03	0	0	13.16	-8.13
Grassland converted to Settlements						
		5.03	0	0	1.86	3.17
Wetlands converted to Settlements						
		5.03	0	0	1.86	3.17
Otherland converted to Settlements						
		5.03	0	0	0	5.03

Dead organic matter

CSC converted to settlements from forest lands are calculated based on the below coefficients and EF. The CSC for other conversions are assumed to be not occurring. It is assumed that there is no DOM in non-Forestland.

Table 6.36 Coefficients and DOM CS values for L-SL subcategories

Ecozones	Forest type	CF litter	CF Dead Wood	CSC LT (tC/ha/yr)	CSC DW (tC/ha/yr)	CSC DOM (tC/ha/yr)
Forest land converted to Wetland						
i.e. Mediterranean Mountain zone	Forest Deciduous	0.37	0.50	-3.09	-0.49	-3.58
	Forest Coniferous	0.37	0.50	-7.51	-0.36	-7.87
	Forest Mixed	0.37	0.50	-5.30	-0.42	-5.72
	Forest Degraded	0.37	0.50	0.00	-0.03	-0.03

Mineral and organic soil

The CSC in mineral soils have been calculated based on national stock values determined by General Directorate of Agricultural Research (TAGEM). The default conversion duration of 20 years has been applied.

It is explained in Section 6.3 Croplands (Mineral and organic soils).

Table 6.37 Coefficients and soil CS values for L-SL subcategories

Ecozone	SOC ref	C stock Settl. (tC/ha)	Forest land C stock (tC/ha)	Cropland (Annual) C stock (tC/ha)	Cropland (perennial) C stock (tC/ha)	Grassland C stock (tC/ha)	Wetland C stock (tC/ha)	Otherl. C stock (tC/ha)
Mediterranean Mountain zone	46.96	20.14	51.53	40.22	46.96	42.26	42.26	12.78
Mediterranean coastal zone deciduous and coniferous forest	37.77	20.14	46.08	29.62	37.77	33.99	33.99	12.78
East Anatolian steppe	47.99	20.14	48.41	38.90	47.99	43.19	43.19	12.78
East Anatolian deciduous forest zone	41.30	20.14	45.14	30.44	41.30	37.17	37.17	12.78
Euxine-Colchic deciduous forest	49.66	20.14	51.90	38.68	49.66	44.69	44.69	12.78
Central Anatolian steppe	40.41	20.14	49.92	32.14	40.41	36.37	36.37	12.78
Aegean Inland deciduous and coniferous forest	42.53	20.14	50.88	30.99	42.53	38.28	38.28	12.78
North Anatolian deciduous, coniferous and mixed forest	54.57	20.14	55.05	34.29	54.57	49.11	49.11	12.78

Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

Table 6.38 Uncertainty summary table for Settlement subcategories

	BY (1990)	LRY (2022)
Settlement Remaining Settlement		
4E1 – SL-SL	0%	0
ΔCC in Living Biomass	NO	NA
Annual Loss Living Biomass (ΔCL)	NO	NA
Annual Gain Living Biomass (ΔCG)	NO	NA
Net C stock change in DOM (ΔCC)	NO	NA
Net C stock change in SOM (ΔCC)	NO	NA
Land Converted to Settlement		
4E2 – L-SL	0%	26%
ΔCC in Living Biomass	NO	24%
Annual Loss Living Biomass (ΔCL)	NO	NA
Annual Gain Living Biomass (ΔCG)	NO	NA
Net C stock change in DOM (ΔCC)	NO	97%
Net C stock change in SOM (ΔCC)	NO	27%

Source-Specific QA/QC and Verification:

The QA/QC procedure has been realized in the framework of a plan developed and carried out by TurkStat the national inventory agency. The sector specific QA/QC has been realized during the LULUCF project activities mentioned above. The calculation procedures have been checked and discussed with the LULUCF experts in and out of the agencies.

Recalculation:

It is explained in Section 6.3 Croplands (4.B) Recalculation.

In the SL category, which was mentioned in the methodology section and recalculated upon the recommendation of ERT, the effect of recalculation was 2.2% on average.

Planned Improvement:

The planned improvements for Settlement category are;

- Update carbon stock changes for all relevant carbon pools for each land use conversion to settlements (MT, LT)
- Extend the study mentioned in the methodology section to other settlement areas and thus update the CS values (MT, LT)

6.7. Other land (4.F)

Source Category Description:

Other land category is a net emission due to land converted to other land. However, the amount of land converted to Other land is quite low. It is assumed that other land may have organic carbon in soils but not in living biomass.

Methodological Issues:

The same conversion principles apply to Other land category. The coefficients and EFs use are as follows;

Table 6.39 The coefficients and EF used in Other land category

EF	Living Biomass	DOM	Soil
Other land	0	0	12.78

The C stocks for living biomass and DOM are assumed to be zero while mineral soil carbon stock is 12.78 based on calculations of General Directorate of Agricultural Research.

It is explained in Section 6.3 Croplands (Mineral and organic soils).

Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

Table 6.40 Uncertainty summary table for Otherland subcategories

	BY (1990)	LRY (2022)
Other land Remaining Other land		
4F1 – OL-OL	0%	0
ΔCC in Living Biomass	NO	NA
Annual Loss Living Biomass (ΔCL)	NO	NA
Annual Gain Living Biomass (ΔCG)	NO	NA
Net C stock change in DOM (ΔCC)	NO	NA
Net C stock change in SOM (ΔCC)	NO	NA
Land Converted to Other land		
4F2 – L-OL	0%	18%
ΔCC in Living Biomass	NO	31%
Annual Loss Living Biomass (ΔCL)	NO	NA
Annual Gain Living Biomass (ΔCG)	NO	NA
Net C stock change in DOM (ΔCC)	NO	139%
Net C stock change in SOM (ΔCC)	NO	19%

6.8. Direct N_2O emissions from N inputs to managed soils (4(I))

Source Category Description:

Emissions and removals from this category as not been calculated since the activity data for N inputs can not be differentiated for the sectors and land uses.

Methodological Issues:

The NO notation key has been used for wetlands and other land. The IE notation key has been used for forest land and settlements since we presume that N inputs are common in urban areas and some specific forestry applications (i.e. nurseries) but are included in the amount used for croplands.

Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

Table 6.41 Uncertainty summary table for 4 (I) category

Summary	BY (1990)	LRY(2022)
Table 4(I)	0%	0%

6.9. Emissions and removals from drainage and rewetting and other management of organic and mineral soils (4(II))

Source Category Description:

There is no reliable data for drainage/rewetting and other management of organic and mineral soils. The category has been reported as NO.

Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

Table 6.42 Uncertainty summary table for 4 (II) category

Summary	BY (1990)	LRY (2022)
Table 4(II)	0%	0%

6.10. N_2O emissions from N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils (4(III))

Source Category Description:

N2O emissions from N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils have been estimated and reported, according to the 2006 IPCC Guidelines, under this category. N2O emissions from land use conversions are derived from mineralization of soil organic matter resulting from the conversions that result in C losses.

N2O emissions from mineralization occurring on other land use categories' soils were estimated as NO.

Methodological Issues:

Equation 11.8 in IPCC (2006) has been used to calculate the mineralised N resulting from loss of soil organic C stocks in mineral soils through Land-use Change or Management Practices. The emissions due to loss of soil organic C were calculated and reported for all conversions. Gains have not been calculated since IPCC 2006 Guidelines suggest Tier 3 methods in order to calculate gains.

A default value of 15 as the C:N ratio of the soil organic matter has been used for conversions involving land-use change from forest or grassland to cropland. A default value of 10 has been used for conversions or management changes on cropland remaining cropland.

The parameters used in calculations are;

Table 6.43 EFs used for N_2O emissions

Parameter (for 1 tC lost)	C/N=15 (all)	C/N=10 (CL)
C/N ratio	15	10
EF1 (kgN2O-N/kg N)	0.01	0.01
Factor (N2O-N) to (N2O)	1.57	1.57
Aggregated factor (t N2O)	**0.001047619**	**0.001571429**

Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

Table 6.44 Uncertainty summary table for 4 (III) category

Summary	BY (1990)	LRY (2022)
Table 4(I)	0%	75%

Recalculation:

It is explained in Section 6.3 Croplands (4.B) Recalculation.

6.11. Indirect N_2O emissions from managed soils (4(IV))

Source Category Description:

The estimation of indirect N2O emissions follows the 2006 IPCC guidelines (Volume 4, Ch. 11). The indirect N2O emissions from N leaching and runoff from managed soils are estimated based on annual amount of N mineralised in mineral soils associated with loss of soil organic matter due to land-use change (i.e. from direct N2O emissions). Default emission factors have been used accordingly.

Reference to 2006 IPCC equation: Vol. 4., Ch. 11: 11.10

Methodological Issues:

The atmospheric deposition as indirect N2O Emissions from Managed Soils has been reported as IE in this category as sources of N can not be differentiated from Croplands and Grasslands thus reported under 3D(b). However, Nitrogen Leaching and Runoff has been estimated by using the default EFs of IPCC 2006.

Table 6.45 EFs used for N_2O emissions

Parameter	Values
Volatilization fraction: Frac GASF ((kg NH3–N + NOx–N) (kg Napplied) –1)	0.2
EF4(kg N2O–N (kg NH3–N + NOX–Nvolatilised)-1)	0.01
FracLEACH-(H) [N losses by leaching/runoff for regions	0.3
EF5 [leaching/runoff], kg N2O–N (kg N leaching/runoff)	0.0075

Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

Table 6.46 Uncertainty summary table for 4 (IV) category

Summary	BY (1990)	LRY (2022)
Table 4(I)	0%	387%

Recalculation:

Recalculation effect is included under other categories.

6.12. Biomass Burning (4(IV))

Estimated effect of mega forest fires in Türkiye in 2021 was 10 460 kton CO_2 eq. emission for Forest Land category from 134.8 kha burned forest area.

Source Category Description:

Several types of country-specific data have been collected to estimate emissions from biomass burning. The most important input variable is activity data (i.e. area burnt) that is collected each year. The second important variable to be collected is above-ground biomass of lands that were affected by wildfires. In addition, Türkiye also collects country-specific data on types of wildfires, carbon pools affected and the fraction of biomass lost in wildfires.

Methodological Issues:

To calculate emissions from wildfires;

- Average above-ground biomass of those forest types (coniferous, deciduous, mixed and OFL) that were affected by wildfires were calculated on an annual basis.
- Average fraction of biomass lost in wildfires was estimated.

Emission estimation due to biomass burning follows the 2006 IPCC guidelines (Volume 4, Ch. 2 and Ch. 4). Currently, CO2 emissions from biomass burning are estimated as part of annual carbon loss in biomass (i.e. Ldisturbance). A generic approach for estimating the amount of carbon lost from disturbances is applied, based on area affected by disturbance (i.e. area burnt), average above-ground biomass on area burnt and average fraction of biomass lost in wildfires. Non-CO2 emissions from biomass burning have also been estimated by applying a generic methodology for each greenhouse gas through use of default emission factors (i.e. for CO, CH_4, N_2O, NOx and NMVOC).

Field burning of agricultural residues is estimated under the Agriculture sector (CRT table 3.F). Controlled burning is not a practice used in Türkiye. Thus reported as NO. Wildfires in wetlands are reported as NO. Most of the wildfires in the GL areas are caused by forest fires and they are reported as NA because the activity data cannot be reached clearly.

Reference to the 2006 IPCC equations: Vol. 4., Ch. 2: 2.14 / 2.27

The EFs and coefficients used are as follows;

Table 6.47 EFs used for Biomass burning emissions

Parameters	Year										
	1990	1995	2000	2005	2010	2015	2018	2019	2020	2021	2022
ABG Dec (tDM/ha)	98.50	102.49	107.61	127.34	128.00	112.87	106.88	96.84	95.05	79.93	80.02
ABG Con (tDM/ha)	71.09	73.98	77.67	83.75	86.12	85.79	87.88	90.34	85.80	72.23	71.52
ABG Mixed (tDM/ha)	84.80	88.23	92.64	105.55	107.06	99.33	97.38	93.59	90.42	76.08	75.77
ABG Degraded (tDM/ha)	5.78	6.02	6.32	6.52	5.57	4.64	4.19	5.78	5.94	4.39	4.43
R For Dec	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
R For Con	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
R For Mix	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
R For Deg	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
LB total Dec (tDM/ha)	127.07	132.22	138.82	164.27	165.12	145.60	137.88	124.92	122.61	103.11	103.23
LB total Con (tDM/ha)	87.45	90.99	95.53	103.01	105.93	105.53	108.09	111.12	105.54	88.85	87.97
LB total Mixed (tDM/ha)	106.84	111.18	116.73	132.99	134.90	125.16	122.70	117.92	113.94	95.87	95.47
LB total Degraded (tDM/ha)	8.27	8.60	9.03	9.32	7.96	6.64	5.99	8.26	8.50	6.29	6.34
LT Dec (tDM/ha)	8.35	8.35	8.35	8.35	8.35	8.35	8.35	8.35	8.35	8.35	8.35
LT Con (tDM/ha)	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30
LT Mix (tDM/ha)	14.32	14.32	14.32	14.32	14.32	14.32	14.32	14.32	14.32	14.32	14.32
LT Deg (tDM/ha)	0.00	5.00	10.00	15.00	20.00	25.00	27.00	28.00	29.00	30.00	31.00
DW Dec (tDM/ha)	0.99	1.02	1.08	1.27	1.28	1.13	1.07	0.97	0.95	0.80	0.80
DW Con (tDM/ha)	0.71	0.74	0.78	0.84	0.86	0.86	0.88	0.90	0.86	0.72	0.72
DW Mix (tDM/ha)	0.85	0.88	0.93	1.06	1.07	0.99	0.97	0.94	0.90	0.76	0.76
DW Deg (tDM/ha)	0.06	0.06	0.06	0.07	0.06	0.05	0.04	0.06	0.06	0.04	0.04
Burned share Dec	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Burned share Con	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90

Table 6.47 EFs used for Biomass burning emissions (Cont'd)

Parameters	1990	1995	2000	2005	2010	2015	2018	2019	2020	2021	2022
Burned share Mix	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Burned share Deg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total stock available for burning (tDM/ha)	105.00	109.35	115.03	129.25	132.07	125.52	125.41	124.27	118.97	100.35	99.65
Cf (combustion factor, Extra tropical forest)	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
FLremFL Amount burnt (tDM/ha)	46.20	48.11	50.61	56.87	58.11	55.23	55.18	54.68	52.35	44.15	43.85
convFL Amount burnt (tDM/ha)	11.11	8.11	8.11	8.11	8.11	7.96	7.96	7.96	7.96	7.96	7.96

Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

Table 6.48 Uncertainty summary table for 4 (IV) category

Summary	BY (1990)	LRY (2022)
Table 4(I)	54%	54%

Recalculation:

There is no recalculation for this submission in this category.

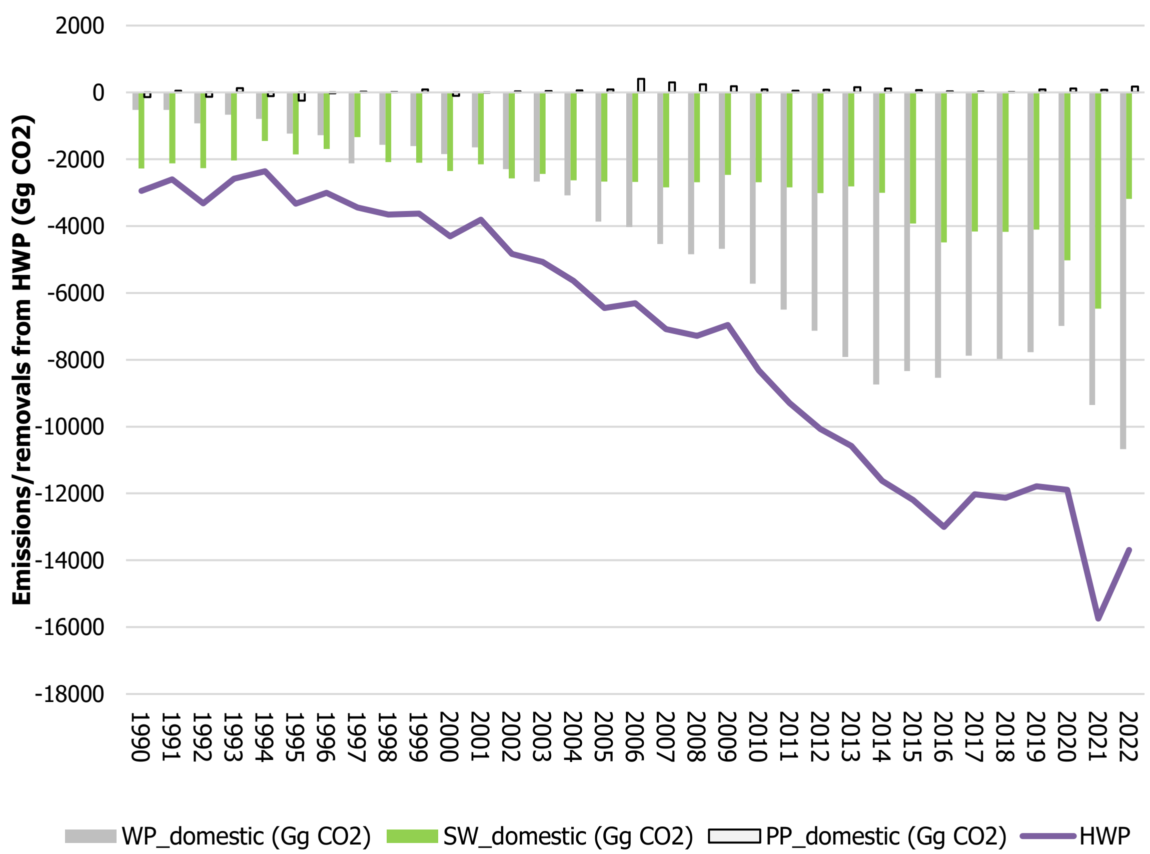
6.13. Harvested Wood Products (4.G)

Source Category Description:

Carbon stock changes of the HWP category calculations have been revised and recalculated in this submission. The previous computation was done in the context of a study by Bouyer and Serengil (2014). The revision involved below changes;

- The approach has been reviewed by international experts and modified based on their suggestions,
- Paper has been added as the third product since 2019 submission (for 1990-2017),
- A KP analogical approach has been employed. Export and import amounts have been taken into account,

Figure 6.21 Emissions and removals in HWP pool



Methodological Issues:

The following methodology has been applied in calculations;

The activity data on various forest products (sawnwood, wood panels and paper) variables for HWP has been downloaded from the FAO database: http://www.fao.org/faostat/en/#data/FO. It is assumed that paperboard is part of the paper category. The data on production of industrial roundwood (production, import, export) and production of wood pulp (production, import, export) have been obtained from the FAO database and annual fraction (i.e. share) of domestic harvest calculated accordingly.

Approach B has been used for HWP calculations. General method to estimate annual change in carbon stock in "products in use" based on first order decay function and half-life is used. Domestic consumption is computed from production data (domestic harvest) plus imports minus exports. The annual fraction of the feedstock coming from domestic harvest for the HWP categories sawnwood and wood-based panels has been estimated. Also, the annual fraction of domestically produced wood pulp as feedstock originating from domestic harvest for the production of the HWP category paper and paperboard (IPCC 2014) is estimated.

Annual carbon stock inflow from domestic wood production for each category was extrapolated backward by applying equation 12.6 to get figures for period before 1961 because FAO statistics start from 1961 (annual rate of increase for industrial roundwood production can be used from table 12.3; for Europe the U value = 0.0151).

Country specific wood density values have been used.

Reference to 2014 IPCC equations: Ch. 2: 2.8.1 / 2.8.2

Reference to 2014 IPCC table: Ch. 2: 2.8.1

Reference to 2006 IPCC equation: Vol. 4., Ch. 12: 12.6

Default half-lives from Table 2.8.2 were used for each HWP category in the FOD constant (k) and the estimation from the year 1900 to present has been performed. Annual CSC in the HWP pool was calculated as difference between subsequent years for the whole reporting period, i.e. base year to present ($\Delta Ci = Ci - Ci\text{-}1$).

Reference to 2006 IPCC equation: Vol. 4., Ch. 12: 12.1

Reference to 2014 IPCC table: Ch. 2: 2.8.2

Recalculation:

There is no recalculation on Harvested Wood Products category for this submission.

7. WASTE (CRT Sector 5)

7.1. Sector Overview

The waste sector includes CH_4 emissions from solid waste disposal, CH_4 and N_2O emissions from biological treatment of solid waste, CO_2, CH_4 and N_2O emissions from open burning of waste and, CH_4 and N_2O emissions from wastewater treatment and discharge. Emissions from waste incineration are included in the inventory but reported in the energy sector since the purpose of waste incineration is energy recovery.

Total waste emissions for the year 2022 are 16.3 Mt CO_2 eq., or 2.9% of total GHG emissions (without LULUCF). Within the sector, 65.2% of the emissions were from solid waste disposal, followed by 34.6% from wastewater treatment and discharge, 0.13% from biological treatment of solid waste and 0.07% from open burning of waste.

The major GHG emissions from the waste sector are CH_4 emissions, which represent 86.8% of total emissions from this sector in 2022, followed by N_2O emissions with 13.2% and a very small percent of CO_2 as 0.03%.

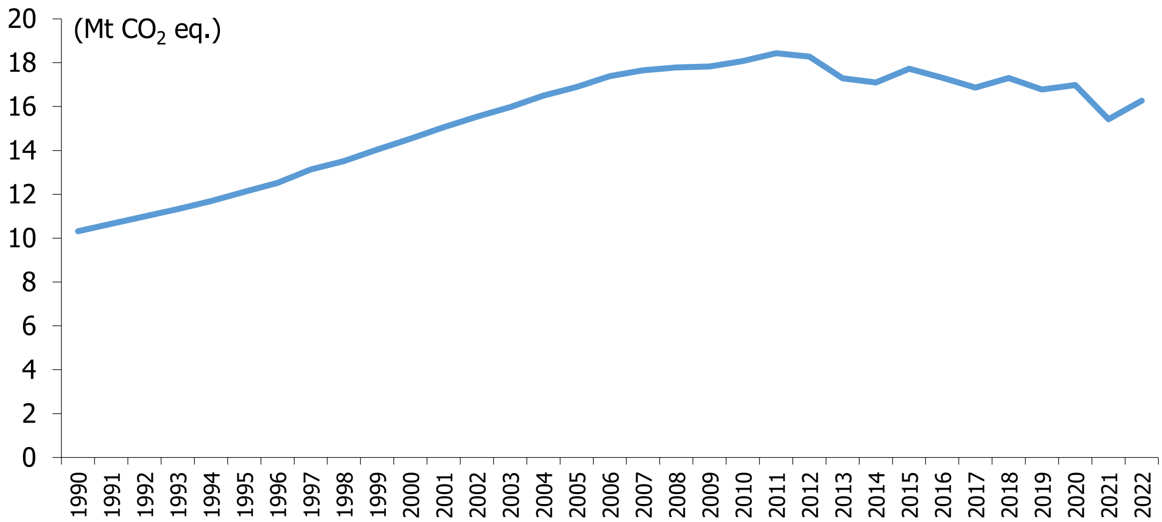
Table 7.1 CO_2 equivalent emissions for the waste sector, 2022

(kt CO_2 eq.)

GHG source and sink categories	CO_2	CH_4	N_2O	Total
5. Waste	5.3	14 119.4	2 140.1	16 264.9
A. Solid waste disposal	NA	10 612.8	NA	10 612.8
B. Biological treatment of solid waste	NA	13.0	7.4	20.4
C. Incineration and open burning of waste	5.3	5.7	0.8	11.8
D. Wastewater treatment and discharge	NA	3 488.0	2 131.9	5 619.9
E. Other	NO	NO	NO	NO

Waste emissions are 57.7% (5.9 Mt CO_2 eq.) higher in 2022 than they were in 1990 and 5.5% (0.8 Mt CO_2 eq.) higher than in 2021 as seen in Figure 7.1.

Figure 7.1 Total GHG emissions of waste sector, 1990-2022



Total emissions in the waste sector gradually increased between 1990 (10 316 kt CO_2 eq.) and 2022 (16 265 kt CO_2 eq.) driven largely by the steady rise in emissions from solid waste disposal between 1990 and 2011 followed by a decrease in emissions since from solid waste disposal after 2011. Emissions from solid waste disposal increased by 132% (7 641 kt CO_2 eq.) between 1990 and 2011, before decreasing by 21% between 2011 and 2022 (2 816 kt CO_2 eq.). Methane recovery in solid waste disposal sites is reported as of 2002 (42 kt CO_2 eq.) and increasing to 10 922 kt CO_2 eq. in 2022. The decline in recent total emissions is mainly due to the increase in methane recovery between 2011 (1 103 kt CO_2 eq.) and 2022, an increase of 890%. For the full discussion of trends for individual categories, see the category-specific discussions below.

Methodological tiers and EFs used to estimate emissions from waste sector are summarized by categories in Table 7.2.

Table 7.2 Summary of methods and emission factors used

	CO_2		CH_4		N_2O	
GHG source and sink categories	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**
5. Waste	T2	CS,D	T1,T2	CS,D	T1	D
A. Solid waste disposal	NA	NA	T2	CS,D	NA	NA
B. Biological treatment of solid waste	NA	NA	T1	D	T1	D
C. Incineration and open burning of waste	T2	CS,D	T1	D	T1	D
D. Wastewater treatment and discharge	NA	NA	T2	CS	T1	D

D: IPCC Default, CS: Country Specific, NA: Not Applicable, T1: Tier 1, T2: Tier 2

7.2. Solid Waste Disposal (Category 5.A)

Source Category Description:

This category includes emissions from solid waste disposal sites (SWDS). The category consists of two waste disposal practices in Türkiye:

- Managed waste disposal sites,
- Unmanaged waste disposal sites.

There are no semi-aerobic managed waste disposal sites (5.A.1.b) in Türkiye and all managed waste disposal sites are categorized under anaerobic managed waste disposal sites (5.A.1.a). Unmanaged waste disposal sites (5.A.2) cannot be classified into deep and shallow due to lack of knowledge. The category covers CH_4 emissions from two types of waste in municipal SWDS in Türkiye:

- Municipal solid waste (MSW),
- Industrial waste,
- Sewage sludge, and
- Clinical waste.

According to the clinical waste management practices and regulations in Türkiye, clinical waste which is collected separately from health institutions is disposed of in SWDS or incinerated. Almost all of the clinical waste is sterilized prior to disposal in SWDS. Hazardous wastes are disposed in separated lots in SWDS. Hazardous wastes are not taken into account in this source category because these types of wastes are not producing methane. Industrial waste including hazardous and clinical waste is usually incinerated and considered in the category of Public Electricity and Heat Production (1.A.1.a).

The total amount of waste disposed in the SWDS has increased through the years mainly due to population growth (Table 7.7). The number of managed SWDS has also increased over the years (Table 7.4) and the share of managed SWDS as a fraction of total SWDS surpassed unmanaged SWDS as of from 2012 onwards, particularly due to improved landfill management practices, including landfill gas recovery.

Since 2004, Türkiye has carried out many actions related to waste management and regulatory policies. The first legal regulation in this field in Türkiye was the Solid Waste Control Regulation (14.03.1991) which provided for and guided practices in the collection and removal of domestic and industrial waste. Revisions of the regulation to harmonize it with the EU Landfill policy were carried out in 2010 (26.03.2010). Waste Management Action Plan covering 2008-2012 was prepared by the former Ministry of Environment and Forestry (MoEF), using the outcomes of the EU funded Environmental Heavy Cost Investment Planning (EHCIP) Project, solid waste master plan projects and the EU Integrated Environmental Adaptation Strategy (NES) (2007-2023). The former Ministry of Environment and

Urbanization (MoEU) published the National Waste Management and Action Plan (2016-2023) in December 2017, in order to set goals for local authorities in all 81 provinces towards an integrated waste management system, which will require more recovering, recycling and energy production from waste and accordingly limit the number of landfills needed as it is aimed at in circular economies. All these waste management policies and actions in Türkiye have reduced the share of GHG emissions from the waste sector.

Methodological Issues:

Methane Emissions from Solid Waste Disposal

CH_4 emissions from solid waste disposal is a key category according to both a level and a trend assessment. CH_4 emissions of MSW, industrial waste, sewage sludge and clinical waste emissions are estimated from municipal SWDS in Türkiye. The IPCC T2 First Order Decay (FOD) method recommended in the 2006 IPCC Guidelines for National GHG Inventories is used with default parameters and country-specific AD on current and historical waste disposal at SWDS to estimate CH_4 emissions. Closed SWDS continue to emit CH_4. This is automatically accounted for in the FOD method because historical waste disposal data are used. The CH_4 emissions from solid waste disposal for a single year can be estimated based on *Equation 3.1 in 2006 IPCC, Volume 5, Chapter 3* as given in the equation below.

$$CH_4\ Emissions = \left[\sum_x CH_4 generated_{x,T} - R_T\right] \bullet (1 - OX_T)$$

Where:

CH_4 Emissions = CH_4 emitted in year *T*, Gg

T = inventory year

x = waste category or type/material

R_T = recovered CH_4 in year *T*, Gg

OX_T = oxidation factor in year *T*, (fraction)

The CH_4 generated by each category of waste disposed is added to get total CH_4 generated in each year. Finally, emissions of CH_4 are calculated by subtracting the CH_4 gas recovered from the disposal site.

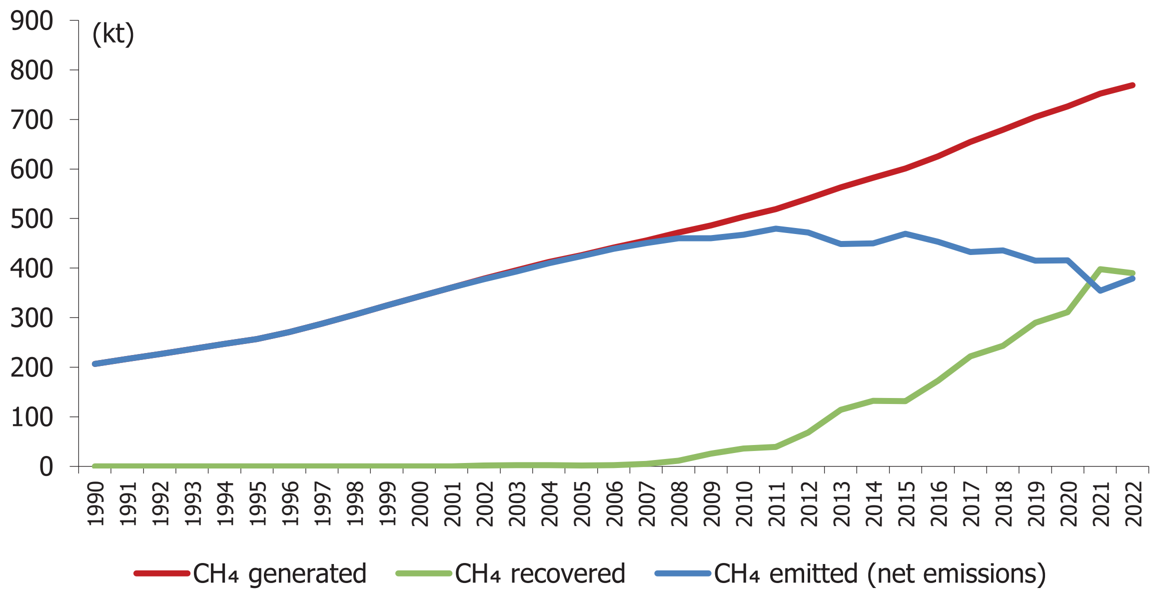
The total amount of CH_4 generated, CH_4 recovered and net CH_4 emissions from solid waste disposal sites are estimated as given in Table 7.3 and Figure 7.2.

Table 7.3 CH_4 generated, recovered and emitted from SWDS, 1990-2022

(kt)

Year	CH_4 Generated	CH_4 Recovered		CH_4 Emitted	
		Managed	Unmanaged	Managed	Unmanaged
1990	206.7	NO	NO	NO	206.7
1995	257.1	NO	NO	5.1	252.0
2000	342.5	NO	NO	41.3	301.2
2005	426.0	1.7	NO	94.9	329.4
2010	503.4	36.3	NO	128.9	338.3
2011	519.0	39.4	NO	144.4	335.3
2012	540.6	68.6	NO	138.3	333.8
2013	562.9	109.5	4.4	122.9	326.0
2014	582.1	128.4	4.0	128.5	321.3
2015	600.9	127.6	4.0	151.5	317.8
2016	625.8	169.7	3.0	138.5	314.6
2017	654.6	214.3	7.9	125.6	306.8
2018	679.1	236.8	6.5	131.9	303.9
2019	704.8	282.6	7.0	118.3	296.8
2020	726.6	308.6	2.2	120.6	295.2
2021	752.2	396.2	1.6	66.2	288.1
2022	769.1	388.8	1.2	95.5	283.5

Figure 7.2 CH_4 emissions from solid waste disposal, 1990-2022



Net methane emissions tend to decrease with the increase in methane recovery amount due to the increase in the capacity and number of methane recovery facilities producing electricity/heat energy from landfill gas in Türkiye.

Choice of Activity Data

For calculating CH_4 generated; municipal solid waste AD, industrial waste AD, sewage sludge AD and clinical waste AD are needed. As is described in more detail below, for MSW, industrial waste, sewage sludge and clinical waste, national data are used where possible, depending on availability of all ADs. If national data are not available for a specific inventory year, population data and waste per capita data are used to estimate national data on MSW generation. By the same logic, GDP data and waste generation rate data are used as drivers for estimating industrial waste generation and some missing data imputation methods were implied for sludge and clinical waste data when any year's data is missing.

The percentage of waste generated which goes to SWDS (% to SWDS) and composition of waste going to SWDS are also used for the calculations.

The distribution of site types is used for calculating a weighted average methane correction factor (MCF). The other parameters needed for the FOD model are; degradable organic carbon (DOC), fraction of DOC which decomposes (DOC_F), methane generation rate constant (k), fraction of methane (F) and oxidation factor (OX).

The justification for the selection of parameters by Türkiye is further described below.

Municipal Solid Waste Activity Data

The annual data of MSW disposed in the municipal SWDS (the amount of MSW both in managed and unmanaged landfills) are collected by TurkStat from *Municipal Waste Statistics Survey* which is applied to all municipalities. However, the survey could not be conducted on a regular basis before 2006, and since 2006 has started to be held biennially. The data for years 1994-1998, 2001-2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022 are available. The specific data collected by TurkStat are the amount of MSW is weighed, generally based on waste delivery vehicle capacity. 2005 data of MSW disposed in managed SWDS is gathered via *Waste Disposal and Recovery Facilities Statistics Survey* by TurkStat. In Türkiye, managed SWDS are in operation since 1992 (See Table 7.4). In 1992 and 1993, there was only one managed SWDS according to the results of *Municipal Waste Statistics Survey*. Therefore, the waste disposal amounts of that site for those years are used for emission estimations (see Table 7.6). Missing data for the years not surveyed for total MSW delivered to SWDS are estimated by regression model. For distribution of MSW to managed and unmanaged landfills between 1990 and 2022, the missing data for the remaining years are estimated by linear interpolation. 2021 data of MSW disposed in managed SWDS has been recalculated by linear interpolation in this inventory submission due to availability of 2022 survey data.

Data are generally available from the statistical surveys described above (noting the need to resolving data gaps for intervening years when survey data were not available). Data on MSW generation were not available prior to 1994. Recognizing that, in accordance with the 2006 IPCC Guidelines, data on MSW generation are needed for at least the last 50 years, Türkiye has made assumptions to collect the full time series of data. As described further below, between 1950 and 1993, the amount of waste generated is estimated based on the waste per capita ratio in 1994 and mid-year population data for each year.

The total number of managed SWDS has increased by years as shown in Table 7.4 below.

Table 7.4 Number of managed SWDS, 1992-2022

1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003
1	1	2	6	6	8	8	10	12	12	15

2004	2005	2006	2008	2010	2012	2014	2016	2018	2020	2022
16	18	22	37	52	80	113	134	159	174	191

Source: (1) TurkStat, Municipal Waste Statistics, 1992-2010

(2) TurkStat, Waste Disposal and Recovery Facilities Statistics, 2012-2022

Amount of municipal waste by disposal methods are given in Table 7.5.

Table 7.5 Amount of municipal waste by disposal methods, 1994-2022

(kt)

Year	Municipality's dumping site	Controlled landfill site	Composting plant	Burning in an open area	Lake and river disposal	Burial	Other (1)
1994	14 479.2	809.0	192.1	442.1	557.6	523.4	753.3
1995	17 174.9	1 444.0	158.9	405.0	370.4	828.9	527.3
1996	17 519.5	2 847.0	178.8	437.9	370.3	823.6	303.3
1997	16 805.1	4 363.8	180.4	625.1	384.4	1 446.9	365.8
1998	16 852.8	5 257.9	166.3	386.1	374.9	852.4	1 039.1
2001	14 569.8	8 304.2	218.1	343.6	100.9	481.7	1 115.4
2002	16 310.0	7 047.0	383.1	220.5	196.8	499.9	715.8
2003	16 566.5	7 431.8	325.9	258.5	228.5	597.0	709.3
2004	16 415.8	7 001.5	350.7	101.6	154.7	426.5	562.7
2006	14 941.2	9 428.3	254.9	246.5	69.8	144.5	194.7
2008	12 677.1	10 947.4	275.7	239.3	47.7	100.5	73.1
2010	11 001.2	13 746.9	194.5	133.9	44.0	34.3	122.1
2012	9 771.0	15 484.2	154.7	104.8	33.4	94.3	202.3
2014	9 935.6	17 807.4	126.5	4.3	15.8	7.3	113.8
2016	9 094.9	19 337.9	146.5	10.2	0.5	6.7	41.1
2018	6 520.7	21 643.8	122.9	6.1	0.5	2.0	65.3
2020	5 492.8	22 443.5	117.5	19.0	0.5	6.9	98.0
2022	4 092.7	20 430.1	209.1	31.1	0.7	28.4	114.0

Source: TurkStat, Municipal Waste Statistics

(1) Data refers to disposals by using as filling material and dumping onto land.

The amount of waste disposed in unmanaged SWDS consists of the amount of waste disposed to municipality's dumping sites, burial and other. Annual municipal solid waste at the SWDS and distribution of waste by waste management type are given in Table 7.6.

Table 7.6 Annual MSW and distribution of waste by management type, 1990-2022

	Annual MSW at the SWDS (kt)			Distribution of waste (%)	
Year	**Total**	**Managed**	**Unmanaged**	**Managed**	**Unmanaged**
1990	15 518.4	NO	15 518.4	0.0	100.0
1995	19 975.1	1 444.0	18 531.1	7.2	92.8
2000	23 894.1	7 288.8	16 605.3	30.5	69.5
2005	25 947.4	7 078.2	18 869.2	27.3	72.7
2010	24 904.4	13 746.9	11 157.5	55.2	44.8
2011	26 319.0	14 615.5	11 703.5	55.5	44.5
2012	25 551.8	15 484.2	10 067.6	60.6	39.4
2013	25 267.0	16 645.8	8 621.2	65.9	34.1
2014	27 864.2	17 807.4	10 056.8	63.9	36.1
2015	27 415.0	18 572.7	8 842.3	67.7	32.3
2016	28 480.5	19 337.9	9 142.6	67.9	32.1
2017	28 837.0	20 490.9	8 346.1	71.1	28.9
2018	28 231.7	21 643.8	6 587.9	76.7	23.3
2019	28 633.6	22 043.7	6 590.0	77.0	23.0
2020	28 041.2	22 443.5	5 597.7	80.0	20.0
2021	28 417.9	21 436.8	6 981.1	75.4	24.6
2022	24 665.2	20 430.1	4 235.1	82.8	17.2

Population Data: Historical data are obtained from TurkStat's *Mid-year Population Estimations and Projections* from 1990 onwards as given in Table 7.7.

Table 7.7 Mid-year population, 1990-2022

Year	Population	Year	Population
1990	55 120 000	2007	70 158 000
1991	56 055 000	2008	71 052 000
1992	56 986 000	2009	72 039 000
1993	57 913 000	2010	73 142 000
1994	58 837 000	2011	74 224 000
1995	59 756 000	2012	75 176 000
1996	60 671 000	2013	76 148 000
1997	61 582 000	2014	77 182 000
1998	62 464 000	2015	78 218 000
1999	63 364 000	2016	79 278 000
2000	64 269 000	2017	80 313 000
2001	65 166 000	2018	81 407 000
2002	66 003 000	2019	82 579 000
2003	66 795 000	2020	83 385 000
2004	67 599 000	2021	84 147 000
2005	68 435 000	2022	84 980 000
2006	69 295 000		

Source: TurkStat, Mid-year Population Estimations and Projections

Waste Per Capita: To calculate waste per capita (kg/cap/yr), the amount of MSW generated and mid-year population data are used. The amount of MSW generated for the surveyed years (1994-1998, 2001-2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022) are obtained from TurkStat's *Municipal Waste Statistics.* The estimations of TurkStat are used for the years 1999, 2000, 2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019 and 2021. In previous submissions, the waste per capita of 1994 (398.5 kg/cap/yr) was used for the years 1950-1993 due to lack of historical MSW generated data. Based on the ERT recommendation (ID#W.5) in the latest review (Report on the individual review of the inventory submission of Türkiye submitted in 2023), Türkiye estimated the historical waste generation for 1950-1993 using gross domestic product as driver, and revised the waste per capita for those years and, accordingly, the CH_4 emission estimates for the entire time series.

Waste per capita for 1990-2022 are given in Table 7.8.

Table 7.8 Waste per capita, 1990-2022

Year	MSW Generated (kt)	Population (millions)	Waste per capita (kg/cap/yr)
1990	21 597.1	55.1	391.8
1995	27 234.1	59.8	455.8
2000	30 617.0	64.3	476.4
2005	31 351.9	68.4	458.1
2010	29 733.0	73.1	406.5
2011	30 862.0	74.2	415.8
2012	30 786.0	75.2	409.5
2013	30 920.0	76.1	406.1
2014	31 230.0	77.2	404.6
2015	31 283.0	78.2	399.9
2016	33 763.5	79.3	425.9
2017	34 173.0	80.3	425.5
2018	34 532.6	81.4	424.2
2019	35 017.4	82.6	424.0
2020	34 757.8	83.4	416.8
2021	35 022.1	84.1	416.2
2022	32 422.2	85.0	381.5

% to SWDS: To calculate percentage of MSW generated which goes to SWDS, the amount of MSW generated and MSW landfilled data are used. The amount of MSW landfilled for the surveyed years (1994-1998, 2001-2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022) are obtained from TurkStat's *Municipal Waste Statistics Survey.* The estimations of TurkStat are used for the years 1999, 2000, 2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019 and 2021. Due to lack of MSW generated data, % to SWDS of 1990 is used for 1950-1989.

% to SWDS obtained by dividing the amount of MSW landfilled by MSW generated are given for 1990-2022 in Table 7.9.

Table 7.9 Percentage of MSW disposed in the SWDS, 1990-2022

Year	MSW Generated (kt)	MSW Landfilled (kt)	% to SWDS (%)
1990	21 597.1	15 518.4	71.9
1995	27 234.1	19 975.1	73.3
2000	30 617.0	23 894.1	78.0
2005	31 351.9	25 947.4	82.8
2010	29 733.0	24 904.4	83.8
2011	30 862.0	26 319.0	85.3
2012	30 786.0	25 551.8	83.0
2013	30 920.0	25 267.0	81.7
2014	31 230.0	27 864.2	89.2
2015	31 283.0	27 415.0	87.6
2016	33 763.5	28 480.5	84.4
2017	34 173.0	28 837.0	84.4
2018	34 532.6	28 231.7	81.8
2019	35 017.4	28 633.6	81.8
2020	34 757.8	28 041.2	80.7
2021	35 022.1	28 417.9	81.1
2022	32 422.2	24 665.2	76.1

Waste Composition Data: The waste composition data was previously only available for 1993, 2006 and 2014. To improve the quality of the inventory, an additional question on waste composition data was added to the TurkStat's *Municipal Waste Statistics Survey,* and the results of the survey as of 2016 were used in the calculations. For 1993, the source of the data is *TurkStat, Environmental Statistics, Household Solid Waste Composition and Tendency Survey Results, 1993*. The results of this survey on a national scale are also published in *OECD Environmental Data, Compendium 2006-2008*. The 2006 data was developed under the Solid Waste Master Plan Project of MoEF and published in *Waste Management Action Plan, 2008-2012; MoEF*. The source of the 2014 waste composition data is *National Waste Management and Action Plan, 2016-2023; MoEU*. The source of waste composition data for the years 2016-2021 is TurkStat's *Municipal Waste Statistics Survey*, as stated above. This survey is conducted biennially, but the waste composition data is compiled annually by inquiring the previous year’s data.

Waste composition data for the remaining years were estimated by time series analysis methods. For missing value imputation R programming language was used. Since, it is not possible to generate missing years before 1993 with interpolation. Thus, for providing time series consistency, time series analysis methods were tried and compared with splicing techniques of IPCC guidelines. After the comprehensive study carried out for imputation of missing years, two of the time series analysis methods were found statistically better than the others. These are Linear Weighted Moving Average (LWMA) and Exponential Weighted Moving Average (EWMA). An exponential moving average is calculated similarly to a linear weighted moving average, but uses an exponentially weighted multiplier. Both of them are calculated by adding the moving average of a certain share of the current value to the previous value. They assign more meaning to the recent values and less to the period's beginning.

LWMA: Weights decrease in arithmetical progression. The observations directly next to a central value i, have weight 1/2, the observations one further away (i-2,i+2) have weight 1/3, the next(i-3,i+3) have weight 1/4, ...

EWMA: uses weighting factors which decrease exponentially. The observations directly next to a central value i, have weight 1/2^1, the observations one further away (i-2,i+2) have weight 1/2^2, the next (i-3,i+3) have weight 1/2^3, ...

(The R Project for Statistical Computing- “Time Series Missing Value Imputation”, Package ‘imputeTS’, Version: 2.7, June 20, 2018)

As a result, LWMA method was preferred because the values of both the first years and the last years were the same in the EWMA method.

Table 7.10 contains these statistically estimated data with the official waste composition data.

Table 7.10 Waste composition data, 1990-2022

(%)

Year	Food	Garden	Paper	Wood	Textile	Plastics	Metal	Glass	Other
1990	58.29	0.95	7.90	0.00	3.81	2.81	1.00	2.76	22.48
1993 (1)	64.00	0.00	6.00	0.00	4.00	3.00	1.00	2.00	20.00
1995	58.00	1.00	8.00	0.00	3.80	2.80	1.00	2.80	22.60
2000	48.00	2.67	11.33	0.00	3.47	2.47	1.00	4.13	26.93
2005	36.45	5.31	14.69	0.00	2.98	2.64	1.06	5.56	31.31
2006 (2)	34.00	5.00	16.00	0.00	3.00	2.00	1.00	6.00	33.00
2010	41.35	5.92	12.06	0.00	2.95	3.93	1.19	4.69	27.92
2011	46.34	5.98	11.44	0.00	2.10	6.23	1.52	4.51	21.88
2012	51.11	6.41	9.52	0.00	1.81	7.80	1.71	3.88	17.77
2013	50.84	6.45	9.36	0.00	1.93	7.58	1.67	3.82	18.33
2014 (3)	48.70	6.84	8.11	0.00	2.90	5.86	1.37	3.38	22.84
2015	52.37	5.67	10.47	0.00	1.09	9.17	1.95	4.34	14.94
2016 (4)	55.13	5.68	11.87	0.00	0.00	11.02	2.28	4.70	9.32
2017 (4)	53.75	3.91	11.91	0.00	0.00	11.36	2.33	5.22	11.53
2018 (4)	54.62	4.96	10.89	0.00	0.00	12.32	2.15	5.13	9.93
2019 (4)	52.71	3.44	9.77	1.24	1.86	11.09	2.09	4.92	12.86
2020 (4)	52.09	2.43	10.26	1.07	1.75	11.30	2.74	5.74	12.62
2021 (4)	55.81	2.99	8.70	0.71	2.99	8.89	2.09	4.42	13.41
2022 (4)	52.77	2.83	8.83	1.18	3.34	9.91	2.07	4.50	14.56

(1) TurkStat, Environmental Statistics, Household Solid Waste Composition and Tendency Survey Results, 1993

(2) MoEF, Waste Management Action Plan, 2008-2012

(3) MoEU, National Waste Management and Action Plan, 2016-2023

(4) TurkStat, Municipal Waste Statistics Survey Results, 2016-2022

Industrial Waste Activity Data

The annual data of industrial waste disposed in the municipal SWDS are collected by TurkStat's *Manufacturing Industry Establishments Water, Wastewater and Waste Statistics Survey* which is applied to manufacturing industry establishments having 50 or more employees. However, the survey could not be conducted on a regular basis before 2008, and since 2008 has started to be held biennially. The data are available for the years 1994-1997, 2000, 2004, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022. The missing data for the remaining years between 1994 and 2022 were estimated by linear interpolation.

Data are available from the statistical surveys described above (noting the need to resolving data gaps for intervening years when survey data were not available). Data on industrial waste generation were not available prior to 1994. Recognizing that, in accordance with the 2006 IPCC Guidelines, data on industrial waste generation are needed for at least the last 50 years, Türkiye has made assumptions to collect the full time series of data. As described further below, between 1950 and 1993, the amount of waste generated is estimated based on the waste generation rate in 1994 and GDP data for each year.

The amount of degradable organic material from industrial waste disposed at SWDS is taken into account since only those industrial wastes which are expected to contain DOC and fossil carbon should be considered for the purpose of emission estimations from SWDS. Excluding the industrial waste that is already included in the Municipal Waste Statistics (to avoid double counting), Türkiye concluded that there are no separately managed industrial waste disposal practices in the SWDS. For this reason, the distribution of industrial waste by waste management type is 100% unmanaged for the whole time series.

The amount of industrial waste disposed of in unmanaged SWDS consists of dumping onto land, burial and disposals to the Organized Industrial Zones.

Annual industrial waste at the SWDS and distribution of waste by waste management type are given in Table 7.11.

Table 7.11 Annual IW and distribution of waste by management type, 1990-2022

	Annual IW at the SWDS (kt)			Distribution of waste (%)	
Year	**Total**	**Managed**	**Unmanaged**	**Managed**	**Unmanaged**
1990	12.9	NO	12.9	0.0	100.0
1995	6.7	NO	6.7	0.0	100.0
2000	10.4	NO	10.4	0.0	100.0
2005	2.7	NO	2.7	0.0	100.0
2010	4.2	NO	4.2	0.0	100.0
2011	4.5	NO	4.5	0.0	100.0
2012	4.7	NO	4.7	0.0	100.0
2013	5.7	NO	5.7	0.0	100.0
2014	6.1	NO	6.1	0.0	100.0
2015	4.0	NO	4.0	0.0	100.0
2016	2.1	NO	2.1	0.0	100.0
2017	2.8	NO	2.8	0.0	100.0
2018	3.4	NO	3.4	0.0	100.0
2019	4.4	NO	4.4	0.0	100.0
2020	5.5	NO	5.5	0.0	100.0
2021	6.7	NO	6.7	0.0	100.0
2022	8.1	NO	8.1	0.0	100.0

GDP Data: Historical data for Gross Domestic Product (GDP) by production approach are obtained from TurkStat's *National Accounts* from 1923 onwards. Compared to the previous submission, GDP data for 2018-2021 has been revised by TurkStat. GDP data in current prices used for emission estimations are given in Table 7.12.

Table 7.12 GDP by production approach, 1990-2022

(million USD)

Year	GDP	Year	GDP
1990	149 195	2007	683 020
1991	149 156	2008	782 865
1992	156 656	2009	651 543
1993	177 332	2010	777 461
1994	131 639	2011	837 924
1995	168 080	2012	877 676
1996	181 077	2013	958 125
1997	188 735	2014	939 923
1998	277 668	2015	867 071
1999	254 119	2016	869 241
2000	273 085	2017	859 055
2001	202 503	2018	797 728
2002	238 145	2019	760 359
2003	316 561	2020	717 141
2004	407 021	2021	807 924
2005	504 754	2022	905 814
2006	552 367		

Source: TurkStat, National Accounts

Waste Generation Rate: To calculate waste generation rate (kt/million USD GDP/yr), between 1950 and 1994, the amount of industrial waste (IW) generated and GDP data are used. As noted above, the amount of IW generated for the surveyed years (1994-1997, 2000, 2004, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022) are obtained from TurkStat's *Manufacturing Industry Establishments Water, Wastewater and Waste Statistics Survey.* Missing data for the years not surveyed (1998, 1999, 2001-2003, 2005-2007, 2009, 2011, 2013, 2015, 2017 and 2019) are estimated by linear interpolation. 2021 waste generation rate of previous submission is recalculated by interpolation method due to availability of 2022 IW data. Due to lack of historical IW generated data, the waste generation rate of 1994 (0.09 kt/million USD GDP/yr) is used for 1950-1993 (see Table 7.13).

% to SWDS: To calculate the percentage of industrial waste generated which goes to SWDS, the amount of industrial waste generated and industrial waste landfilled data are used. The amount of industrial waste landfilled for the surveyed years (1994-1997, 2000, 2004, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022) are obtained from TurkStat's *Manufacturing Industry Establishments Water, Wastewater and Waste Statistics Survey.* 2021 % to SWDS data of previous submission is recalculated by interpolation method due to availability of 2022 IW generated data. Due to lack of industrial waste generated data, the percentage of industrial waste sent to SWDS in 1994 (0.1%) is used for 1950-1993.

The percentage of industrial waste to SWDS is obtained by dividing the amount of industrial waste landfilled by industrial waste generated data.

Industrial waste AD are given in detail in Table 7.13.

Table 7.13 Industrial waste activity data, 1990-2022

Year	GDP (million USD)	Waste generation rate (kt/million USD/yr)	Total IW (kt)	% to SWDS (%)	Total to SWDS (kt)
1990	149 195.0	0.09	13 615.4	0.10	12.9
1995	168 080.0	0.07	12 492.8	0.05	6.7
2000	273 085.5	0.06	17 058.9	0.06	10.4
2005	504 753.8	0.04	18 286.1	0.01	2.7
2010	777 460.5	0.02	13 366.5	0.03	4.2
2011	837 924.3	0.02	14 086.6	0.03	4.5
2012	877 675.6	0.02	14 420.3	0.03	4.7
2013	958 125.3	0.02	15 890.2	0.04	5.7
2014	939 922.9	0.02	15 733.5	0.04	6.1
2015	867 071.4	0.02	15 370.1	0.03	4.0
2016	869 240.6	0.02	16 266.7	0.01	2.1
2017	859 055.3	0.02	20 358.2	0.01	2.8
2018	797 728.3	0.03	22 881.1	0.01	3.4
2019	760 359.1	0.03	23 557.8	0.02	4.4
2020	717 141.0	0.03	23 867.9	0.02	5.5
2021	807 924.3	0.03	25 917.9	0.03	6.7
2022	905 814.3	0.03	27 969.0	0.03	8.1

Methane Correction Factor (MCF)

Due to the assumption that all managed SWDS are categorized under anaerobic managed SWDS, the default MCF from the 2006 IPCC Guidelines for anaerobic managed SWDS (1.0) is taken for managed SWDS. Since there is no information about classification of deep (>=5 meters waste and/or high water table) or shallow (<5 meters waste) for unmanaged waste disposal sites, Türkiye has used the average of the default MCFs for unmanaged-deep (0.8) and unmanaged-shallow (0.4) in the absence of country-specific information for unmanaged waste disposal practices (0.6).

A weighted average of MCF from the estimated distribution of site types is needed for the calculation CH_4 emissions from solid waste disposal sites. Calculated values for the MCF are given in Table 7.14.

Table 7.14 Weighted averages of MCF, 1990-2022

(weighted average fraction)

Year	MCF for MSW	MCF for IW	MCF for SS	MCF for CW
1990	0.60	0.60	0.60	0.00
1995	0.63	0.60	0.60	0.00
2000	0.72	0.60	0.82	0.00
2005	0.71	0.60	0.79	0.78
2010	0.82	0.60	0.74	0.88
2011	0.82	0.60	0.74	0.90
2012	0.84	0.60	0.75	0.92
2013	0.86	0.60	0.75	0.91
2014	0.86	0.60	0.76	0.90
2015	0.87	0.60	0.77	0.91
2016	0.87	0.60	0.77	0.92
2017	0.88	0.60	0.79	0.89
2018	0.91	0.60	0.81	0.88
2019	0.91	0.60	0.80	0.89
2020	0.92	0.60	0.79	0.85
2021	0.90	0.60	0.78	0.81
2022	0.93	0.60	0.77	0.79

Choice of Emission Factor and Other Parameters

2006 IPCC default values are selected for utilization in the IPCC Waste Model using the FOD method with the starting year 1950.

Degradable Organic Carbon (DOC): Degradable organic carbon (DOC) is the organic carbon in waste that is accessible to biochemical decomposition. IPCC default values for the DOC content of main components (waste types/material) used in the model are listed in Table 7.15. For sewage sludge 0.05 is taken and for clinical waste 0.15 is used according to *Table 2.6 in the 2006 IPCC, Volume 5, Chapter 2.*

Table 7.15 DOC values by individual waste type

(weight fraction, wet basis)

Waste Type	Food waste	Garden	Paper	Wood	Textiles
DOC	0.15	0.20	0.40	0.43	0.24

DOC by weight is calculated from the degradable portion of the MSW based on *Equation 3.7 in the 2006 IPCC, Volume 5, Chapter 3* and the IPCC defaults are taken from *Table 2.4 in the 2006 IPCC, Volume 5, Chapter2*.

$$\% \, DOC \; (by \; net \; weight) = (0.15 \, x \, A) + (0.20 \, x \, B) + (0.40 \, x \, C) + (0.43 \, x \, D) + (0.24 \, x \, E)$$

Where:

A = fraction of food waste in MSW

B = fraction of garden waste in MSW

C = fraction of paper in MSW

D = fraction of wood in MSW

E = fraction of textiles in MSW

The calculated values of DOC by weight for the inventory years of 1990-2022 are listed below in Table 7.16.

Table 7.16 DOC by weight, 1990-2022

Year	%DOC	Year	%DOC
1990	13.01	2015	13.44
1995	13.01	2016	14.15
2000	13.10	2017	13.61
2005	13.12	2018	13.54
2010	12.92	2019	13.49
2011	13.23	2020	13.29
2012	13.19	2021	13.47
2013	13.13	2022	13.33
2014	12.61		

Fraction of Degradable Organic Carbon Which Decomposes (DOC_f): In the absence of country-specific information, the recommended IPCC default value for DOC_f (0.5) is used for the entire time series.

Methane Generation Rate Constant (k): IPCC default methane generation rate constants are selected according to the IPCC climate zone definitions in the model. Default k values for dry temperate are listed below and applied for the entire time series.

Table 7.17 Dry temperate k values by waste type

(years^{-1})

Waste Type	Food waste	Garden	Paper	Wood	Textiles
k	0.06	0.05	0.04	0.02	0.04

Fraction of Methane in Generated Landfill Gas (F): Most waste in SWDS generates a gas with approximately 50% CH_4. The IPCC default value for the fraction of CH_4 in landfill gas (0.5) is used for the entire time series.

Oxidation Factor (OX): The oxidation factor reflects the amount of CH_4 from SWDS that is oxidized in the soil or other material covering the waste. The IPCC default value of zero is used for unmanaged SWDS for the entire time series.

Based on the ERT recommendation (ID#W.4) in the latest review (Report on the individual review of the inventory submission of Türkiye submitted in 2023), Türkiye used an oxidation value of 0.1 for managed SWDS and recalculated CH_4 emissions from managed landfills accordingly.

Methane Recovery

The recovery of methane and its subsequent utilization are also included in the inventory. The recovery of methane from landfill gas commenced in Turkey in 2002. Therefore, the quantity of recovered methane is subtracted from the methane produced beginning in the year 2002. In 2013, *Waste Disposal and Recovery Facilities Survey, 2012* was applied to all waste disposal and recovery facilities having a license or a temporary license, and regardless of license, to controlled landfill sites, incineration plants and composting plants operated by or on behalf of municipalities. Based on the information obtained from the survey, TurkStat sends official letters to each facility recovering methane for requesting the quantity of methane gas and electricity/heat production for the entire operating period of the facility every year. The facilities estimate the quantity of methane recovered by measuring of gas recovered. The obtained information on the quantity of produced electricity/heat is used for cross-checking the quantity of methane recovered.

The coverage of the facilities is followed and updated depending on availability of new information; such as information obtained from the facility, the information from the most recent (biennial) survey *(i.e. Waste Disposal and Recovery Facilities Survey, 2022)*. The emissions from energy production from the recovered CH_4 gas in SWDS were included in the category of Public Electricity and Heat Production (1.A.1.a).

Given the high recovery efficiency observed in Türkiye, it is important to provide further clarification on the QA/QC procedure for collecting recovery data. It is essential to note that this procedure is based on documented amounts of metered recovery, with the objective of enhancing transparency. The 2006 IPCC Guidelines (vol. 5, chap. 3, p.3.19) indicate that CH_4 recovery should be reported only when references documenting the amount of CH_4 recovery are available. In addition, the guidelines indicate that if CH_4 recovery is reported, an inventory of known recovery facilities is desirable (vol 5., chap. 3, p.3.28). Methane recovery is not estimated on the basis of the number of SWDS with landfill gas recovery. As consistent with the guidelines, since reporting is based on metering the gas recovery, high efficiency is expected. An inventory of all known recovery facilities is available. Data regarding methane recovery facilities are compiled in accordance with the confidentiality principle of the Turkish Statistical Law No. 5429.

The main reason for the high recovery efficiency in Türkiye is that the number of well-managed methane recovery facilities has increased in recent years, as well as the number of engines in large facilities has almost doubled with government incentives, especially for 2021. Considering the facility capacity, the number did not increase in 2021, but the amount recovered increased significantly. During quality control activities, these facilities were specifically questioned and the reasons can be listed as follows:

- In the facility, which ranks first in Türkiye in terms of the amount of waste collected, a new managed SWDS has been put into operation since 2020. An improvement was made in one of the existing managed SWDS, whose operations were stopped in 2020, and then energy production continued by two separate energy production companies with the newly added production facility in 2021. As a result, the total amount of methane recovered at the facility has tripled compared to 2020.
- The facility, which ranks second in Türkiye in terms of the amount of waste collected, became operational for the first time in 2020.

Administrative records data from methane recovery facilities are compared with survey results from the previous inventory period. Data verification is performed by comparing the amount of methane recovered (facility basis) with the electric/heat energy produced from recovered methane (facility basis) and the amount of waste collected (municipality basis). Cross-checks are made by comparing both the facility's own time series and the amount of electricity/heat quantity information of other facilities. As these data relate to commercial electricity production, the facilities in question provide comprehensive reports on them.

If the data is not verified as a result of these checks, the facility is asked to verify the data. In general, the problem of reporting the amount of landfill gas instead of methane gas has been experienced, and therefore, in recent years, the issue was resolved by contacting the majority of facilities (including a plant visit to one of the largest facilities in 2022, as noted in the *Source-Specific QA/QC and Verification* section) to verify the amount of methane recovered. However, if the facility cannot provide the amount of methane gas, the calculation is made by learning from the facility the percentage of methane gas in the provided landfill gas. In cases where this information cannot be provided, the amount of recovered methane gas is calculated using percentages with literature values after a second confirmation is received from the facility.

All relevant information is clearly documented and archived, along with background information on a site-by-site basis.

The number of managed and unmanaged SWDS with landfill gas recovery and the amount of recovered methane, by year, are given in Table 7.18.

Table 7.18 Methane recovery, 1990-2022

Year	Number of managed SWDS with landfill gas recovery	Number of unmanaged SWDS with landfill gas recovery	Recovered methane in managed SWDS (kt)	Recovered methane in unmanaged SWDS (kt)
1990-2001	NA	NA	NO	NO
2002	1	NA	1.5	NO
2005	1	NA	1.7	NO
2010	5	NA	36.3	NO
2011	8	NA	39.4	NO
2012	13	NA	68.6	NO
2013	15	1	109.5	4.4
2014	17	1	128.4	4.0
2015	24	1	127.6	4.0
2016	34	1	169.7	3.0
2017	36	1	214.3	7.9
2018	48	1	236.8	6.5
2019	51	2	282.6	7.0
2020	68	1	308.6	2.2
2021	64	1	396.2	1.6
2022	79	1	388.8	1.2

An additional question about landfill gas flaring was added to the *Waste Disposal and Recovery Facilities Survey, 2014* and was also asked through the most recent survey, *Waste Disposal and Recovery Facilities Survey, 2022*. There is no official data on landfill gas flaring. It will be also considered in the upcoming inventory in case that new information is obtained.

Sewage Sludge

Sewage sludge is estimated by TurkStat with official data. This sludge is domestic wastewater treatment sludge from municipal wastewater treatment plants. Data on sludge quantity are compiled on wet basis and converted to dry matter by using the coefficients included in the guidelines of the European Union Statistical Office (EUROSTAT). And for the emissions calculations dry basis is used. The source of sewage sludge is TurkStat's *Municipal Wastewater Statistics Survey.* In this survey, disposal methods named 'Dumping on to land', 'Municipal dumping sites', 'Controlled landfill sites', 'Buried' and 'Other disposal' are added together and assumed as the total sludge that stored in SWDS and each sludge amount can be seen from Table 7.37 in Wastewater Treatment and Discharge section (Category 5.D).

Methane emissions from sewage sludge and activity data are listed below in Table 7.19 and Table 7.20, respectively.

Table 7.19 CH_4 generated from SS at SWDS, 1990-2022

(kt)

Year	Total	Managed	Unmanaged
1990	NO	NO	NO
1995	0.004	NO	0.004
2000	0.052	0.026	0.026
2005	0.392	0.242	0.151
2010	1.026	0.552	0.474
2011	1.160	0.606	0.554
2012	1.285	0.658	0.627
2013	1.400	0.708	0.693
2014	1.493	0.751	0.742
2015	1.563	0.787	0.776
2016	1.620	0.817	0.802
2017	1.664	0.842	0.821
2018	1.696	0.867	0.830
2019	1.718	0.891	0.827
2020	1.736	0.909	0.826
2021	1.749	0.922	0.827
2022	1.760	0.930	0.830

Table 7.20 Annual SS and distribution of waste by management type, 1990-2022

	Annual SS at the SWDS (kt)			Distribution of waste (%)	
Year	**Total**	**Managed**	**Unmanaged**	**Managed**	**Unmanaged**
1990-94	1.5	NO	1.5	0.0	100.0
1995	2.4	NO	2.4	0.0	100.0
2000	58.0	32.0	26.0	55.1	44.9
2005	184.6	88.8	95.7	48.1	51.9
2010	283.3	98.8	184.5	34.9	65.1
2011	280.2	100.0	180.2	35.7	64.3
2012	277.0	101.1	175.9	36.5	63.5
2013	250.5	96.3	154.1	38.5	61.5
2014	223.9	91.5	132.4	40.9	59.1
2015	210.0	87.3	122.7	41.6	58.4
2016	196.1	83.0	113.1	42.3	57.7
2017	180.4	84.2	96.2	46.7	53.3
2018	164.6	85.4	79.2	51.9	48.1
2019	161.7	80.5	81.2	49.8	50.2
2020	158.8	75.6	83.2	47.6	52.4
2021	158.4	70.4	88.0	44.5	55.5
2022	158.0	65.3	92.7	41.3	58.7

Clinical Waste

Data have been collected according to the manual for the implementation of regulation (EC) no 2150/2002 on waste statistics and to the framework of the OECD/EUROSTAT core set of environmental data and indicators. For the reference year 2016 and before, data was produced based on the results of the survey conducted by TurkStat which was applied to the health institutions listed in Medical Waste Control Regulation as producers of large quantities of waste (university hospitals and their clinics, general purpose hospitals and their clinics, maternity hospitals and their clinics and military hospitals and their clinics) as Waste Statistics of Health Institutions.

Since 2017, Medical Waste Statistics have been prepared and published annually using medical waste data from the health institutions (university, maternity and general purpose hospitals and their clinics) included in the administrative records of the Ministry of Environment, Urbanization and Climate Change (MoEUCC). Within the scope of the Official Statistics Program (2022-2026), it was decided that the press release, which was previously published jointly by TurkStat and MoEUCC, will be published only by the MoEUCC as of 2022. However, since the statistics for 2022 have not yet been published by the MoEUCC, the amount of medical waste disposed of in landfills has been estimated by extrapolation. The 2021 data estimated in the previous submission has been recalculated due to the published relevant statistics.

Methane emissions caused by clinical waste are quite small as seen in Table 7.21.

Table 7.21 CH_4 generated from CW at SWDS, 1990-2022

(kt)

Year	Total	Managed	Unmanaged
1990-2003	IE	IE	IE
2005	0.2	0.1	0.1
2010	0.6	0.4	0.2
2011	0.7	0.4	0.2
2012	0.7	0.5	0.2
2013	0.8	0.6	0.2
2014	0.9	0.7	0.2
2015	1.0	0.8	0.3
2016	1.1	0.8	0.3
2017	1.2	0.9	0.3
2018	1.3	1.0	0.3
2019	1.4	1.1	0.3
2020	1.5	1.2	0.3
2021	1.6	1.2	0.4
2022	1.7	1.3	0.4

As can be seen from Table 7.22, values before 2003 were entered as "IE". The reason why those years were entered as "Included Elsewhere" is the clinical waste data were gathered by TurkStat in those years included in SWDS statistics via *Municipal Waste Statistics Survey* prior to 2003 because clinical waste was not collected separately before 2003. After 2003, clinical waste was collected separately by municipalities.

Table 7.22 Annual CW and distribution of waste by management type, 1990-2022

	Annual CW at the SWDS (kt)			Distribution of waste (%)	
Year	**Total**	**Managed**	**Unmanaged**	**Managed**	**Unmanaged**
1990-2002	IE	IE	IE	NA	NA
2005	47.7	21.1	26.6	44.3	55.7
2010	54.4	38.1	16.3	70.1	29.9
2011	58.8	44.6	14.2	75.8	24.2
2012	63.2	51.0	12.2	80.7	19.3
2013	65.1	50.8	14.3	78.1	21.9
2014	67.0	50.7	16.3	75.6	24.4
2015	67.7	52.5	15.2	77.6	22.4
2016	68.5	54.4	14.0	79.5	20.5
2017	78.4	56.3	22.0	71.9	28.1
2018	82.6	58.2	24.3	70.5	29.5
2019	83.0	60.1	22.9	72.4	27.6
2020	99.4	62.0	37.4	62.4	37.6
2021	119.2	63.9	55.3	53.6	46.4
2022	139.1	65.8	73.3	47.3	52.7

Uncertainties and Time-Series Consistency:

Uncertainty values for AD are estimated as 10.0% and 30.0% for managed and unmanaged SWDS, respectively. The uncertainty values reflect the uncertainty associated with some of the assumptions made by Türkiye in estimating underlying activity data for municipal solid waste, industrial waste, sewage sludge and clinical waste. Although waste statistics on the amount of MSW generated are not available for all years after 1990, the periodic availability of survey data reduces the uncertainty of these data. The assumption that waste generation per capita prior to 1994 is constant likely overestimates the MSW generation for this time period. Further, estimating MSW generation based on population does not account for the fact that not all of the population may be serviced with waste collection. Combined uncertainty values of EFs are estimated as 30.8% and 38.1% for managed and unmanaged SWDS based on *Table 3.5 in 2006 IPCC, Volume 5, Chapter 3.*

The estimates are calculated in a consistent manner over time series.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

The data used in Solid Waste Disposal (CRT Category 5.A) are derived from waste statistics database of TurkStat. TurkStat is producing all its statistics according to the European Code of Practice Principles. Therefore, high quality data are used in the emission estimates of this category.

A QC activity is also carried out by the inventory expert when the data originate from facility-level data providers. As an example of sector specific QA/QC, survey data are used in one year and administrative records data are used in the other year to compile activity data of methane recovery facilities. Administrative records data from methane recovery facilities are compared with survey results from the previous inventory period. Data verification is performed by comparing the amount of methane recovered (facility basis) with the electric/heat energy produced from recovered methane (facility basis) and the amount of waste collected (municipality basis). Cross-checks are made by comparing both the facility's own time series and the electricity/heat quantity information of other facilities. As these data relate to commercial electricity production, the facilities in question provide comprehensive reports on them.

As part of sector-specific QA/QC, waste and GHG experts from TurkStat made a plant visit to one of the largest facilities in landfill gas recovery in December 2022.

Recalculation:

Major Recalculations: Based on the ERT recommendation (ID#W.5) in the latest review (Report on the individual review of the inventory submission of Türkiye submitted in 2023), Türkiye estimated the historical waste generation for 1950-1993 using gross domestic product as driver, and revised the waste per capita for those years and, accordingly, the CH_4 emission estimates for the entire time series (1990-2021).

Based on the ERT recommendation (ID#W.4) in the latest review (Report on the individual review of the inventory submission of Türkiye submitted in 2023), Türkiye recalculated CH_4 emissions for the entire time series (1993-2021) from managed waste disposal sites, assuming an oxidation factor of 0.1.

Minor Recalculations: 2021 data of MSW disposed in managed SWDS has been recalculated by linear interpolation due to availability of 2022 survey data. The amount of MSW disposed in unmanaged SWDS for 2021 was also affected by this recalculation.

2021 waste composition data is recalculated due to the availability of 2022 survey which includes 2021 and 2022 data.

The revision of 2018-2021 GDP data by TurkStat resulted in changes in total industrial waste in the SWDS, which led to minor recalculation in CH_4 emissions from unmanaged SWDS for the same period. 2021 waste generation rate of previous submission is recalculated by interpolation method due to availability of 2022 IW data. 2021 % to SWDS data of previous submission is also recalculated by interpolation method due to availability of 2022 IW generated data.

Methane recovery data from a landfill gas recovery facility has been recalculated for the year 2020.

In summary, total CH_4 emissions from solid waste disposal sites have been recalculated between the years 1990 and 2021 and over the years, methane emissions have changed in figures ranging from -23.2% to -5.1%.

Planned Improvement:

As noted above, a question has been asked about the flaring of landfill gas in the *Waste Disposal and Recovery Facilities Survey, 2022.* According to the results of the survey, it has been determined that there is no flaring at the waste disposal sites in Türkiye. The results of the next survey *(Waste Disposal and Recovery Facilities Survey, 2024)* will be assessed, and if appropriate, the results incorporated into the next inventory submission(s).

7.3. Biological Treatment of Solid Waste (Category 5.B)

Source Category Description:

This category includes emissions from composting and anaerobic digestion of organic waste. Türkiye reports CH_4 and N_2O emissions from composting of municipal solid waste (5.B.1). Türkiye has no information available on the existence of anaerobic digestion of organic waste. Therefore, consistent with the 2006 IPCC Guidelines, Türkiye assumes that there is no anaerobic digestion in the country. However, this treatment process will be also considered and reported in coming years depending on availability of any information.

The total biological treatment of solid waste emissions for both gases increased by 59.3% (7.6 kt CO_2 eq.) between 1990 (12.8 kt CO_2 eq.) and 2022 (20.4 kt CO_2 eq.).

Methodological Issues:

To estimate both CH_4 and N_2O emissions for composting, Türkiye multiples the mass of organic waste composted by a default emission factor (the IPCC T1 method), as recommended in the 2006 IPCC Guidelines for National GHG Inventories. The CH_4 and N_2O emissions of biological treatment can be estimated using the default method based on *Equations 4.1 and 4.2 in 2006 IPCC, Volume 5, Chapter 4* as given below.

$$CH_4\ Emissions = \sum_i (M_i \bullet EF_i) \bullet 10^{-3} - R$$

Where:

CH_4 Emissions = total CH_4 emissions in inventory year, Gg CH_4

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

EF = emission factor for treatment i, g CH_4/kg waste treated

i = composting or anaerobic digestion

R = total amount of CH_4 recovered in inventory year, Gg CH_4

$$N_2O\ Emissions = \sum_i (M_i \bullet EF_i) \bullet 10^{-3}$$

Where:

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

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

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

i = composting or anaerobic digestion

Collection of Activity Data

As provided in Table 7.5, the amount of municipal solid waste delivered to composting plants (1994-1998, 2001-2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022) are available in TurkStat's *Municipal Waste Statistics*. The amount of composted waste data is available in TurkStat's *Municipal Waste Statistics* for the years 2006, 2008 and 2010, and in TurkStat's *Waste Disposal and Recovery Facilities Statistics* for the years 2005, 2012, 2014, 2016, 2018, 2020 and 2022. The amount of waste composted in Türkiye's largest compost facility, which has been operational since 2001, is available as a continuous time series. The composting plant with the largest share is located in Istanbul, which is the largest city of Türkiye in terms of population. Data from this composting plant were used as surrogate data along with the aforementioned survey data. With all this available data, the 'fraction of waste composted' was used to estimate activity data for the years before 2001. Since the facility information is the same, activity data for the 1990-1993 period is considered the same as 1994.

To summarize the activity data described above, 1990-2000 data were estimated using the 'fraction of waste composted'. 2001-2013 data were obtained by estimating from surrogate data, exculding verified 2012 survey data. As of 2015, the official data on the amount of waste treated by composting plants began to be compiled directly from the relevant facilities for the years where no survey was conducted (2015, 2017, 2019 and 2021). Thus, a complete time series was obtained with existing survey data (2014, 2016, 2018 and 2020).

Based on the ERT recommendation (ID#W.6) in the latest review (Report on the individual review of the inventory submission of Türkiye submitted in 2023), the issue of mechanical biological treatment (MBT) has been studied meticulously. The mechanical operations are only available in the largest facility mentioned and the data for this facility has been provided in full detail. According to the provided information, Türkiye confirms that the previous submission leads to overestimation and the revised time series only include the amount of waste fed into composting. The remaining amount of waste from the previous time series is either sent for disposal or recycling, and waste to disposal are already covered in category 5.A.

As a result of this study, Türkiye differentiated between the amounts of MSW composted and treated in an MBT facility, and for the MSW treated in an MBT facility, quantified the fraction of waste that is composted and use only this fraction as activity data to estimate emissions from composting. In this regard, the 1990-2021 time series has been completely recalculated.

The number of facilities operating each year and the total capacity of composting plants for each year in Türkiye is indicated below.

Table 7.23 Number and total capacity of composting plants, 1994-2022

Year	# of composting plants with installed capacity	# of operating composting plants	Capacity (thousand tonnes/year)
1994-1998	2	NA	245
2001	3	NA	299
2002	4	NA	664
2003	5	NA	667
2004	5	NA	667
2005	4	NA	606
2006	4	NA	605
2008	4	NA	551
2010	5	NA	556
2012	6	6	389
2014	4	3	310
2015	4	3(3)	310
2016	7	5	424
2017	7	5(3)	424
2018	8	6	483
2019	8	6(3)	483
2020	9	7	651
2021	9	6(3)	651
2022	11	7	722

Source: (1) TurkStat, Municipal Waste Statistics, 1994-2010
(2) TurkStat, Waste Disposal and Recovery Facilities Statistics, 2012-2022
(3) Administrative records obtained by official letters

The number of composting plants with installed capacity and the operating ones are provided separately for available years in Table 7.23. Since the official data (number of facilities) of the survey indicates the number of composting plants with installed capacity, not those active ones in the relevant press releases, precise information on the number of facilities operating by year is not available before 2012. For years without survey (2015, 2017, 2019 and 2021), the number and total capacity of composting plants with installed capacity are assumed to be the same as the previous year.

Choice of Emission Factor

EFs of 4.0 g CH_4/kg waste treated (on a wet weight basis) and 0.24 g N_2O/kg waste treated (on a wet weight basis) are selected for the estimates of CH_4 and N_2O emissions respectively, based on *Table 4.1 in the 2006 IPCC Guidelines, Volume 5, Chapter 4.*

The total annual amount of waste treated (as wet weight) by composting plants and emissions from composting are provided in Table 7.24.

Table 7.24 Activity data, CH_4 and N_2O emissions from composting, 1990-2022

(kt)

Year	Amount of waste treated by composting plants	CH_4 Emissions	N_2O Emissions
1990-94	72.9	0.29	0.017
1995	60.3	0.24	0.014
2000	76.2	0.30	0.018
2005	96.9	0.39	0.023
2010	118.9	0.48	0.029
2011	120.4	0.48	0.029
2012	105.1	0.42	0.025
2013	84.1	0.34	0.020
2014	86.6	0.35	0.021
2015	93.4	0.37	0.022
2016	89.9	0.36	0.022
2017	81.8	0.33	0.020
2018	102.4	0.41	0.025
2019	107.5	0.43	0.026
2020	92.6	0.37	0.022
2021	133.7	0.53	0.032
2022	116.1	0.46	0.028

As seen in Figure 7.3, Figure 7.4 and Figure 7.5, the fluctuations of CH_4 and N_2O emissions from composting depend mainly on fluctuations of the amount of waste treated by composting plants (AD). Emissions were relatively stable between 1990 and 2000 due to the same number of operating facilities during that period. A remarkable increase was observed when the dominant facility became operational after 2001. Fluctuations have been observed in recent years due to the change in the number of facilities operating in those years, as provided in Table 7.23.

CH_4 emissions have a maximum value of 0.53 kt in 2021 while having a minimum value of 0.24 kt in 1995. Likewise, N_2O emissions have a maximum value of 0.032 kt in 2021 while having a minimum value of 0.014 kt in 1995.

Figure 7.3 Amount of waste treated by composting plants, 1990-2022

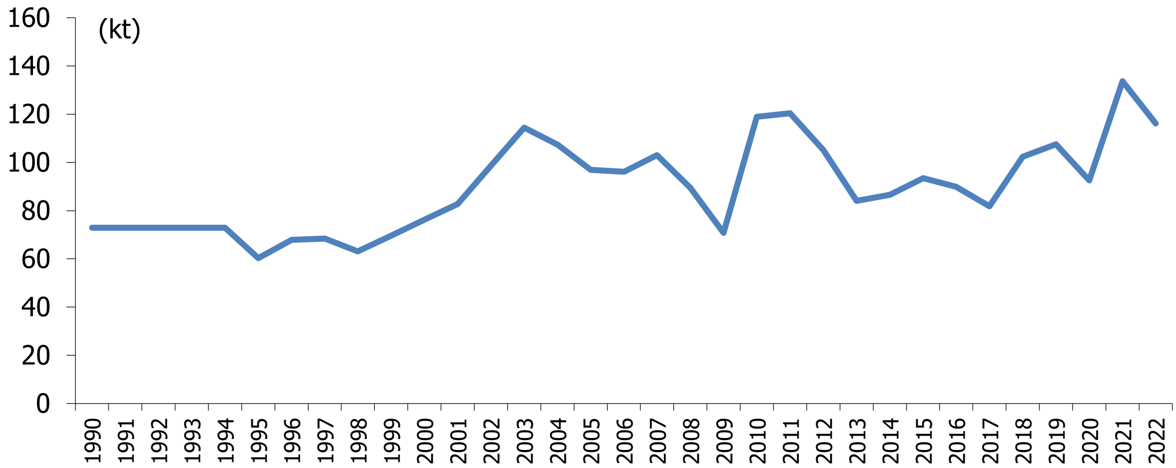


Figure 7.4 CH_4 emissions from composting, 1990-2022

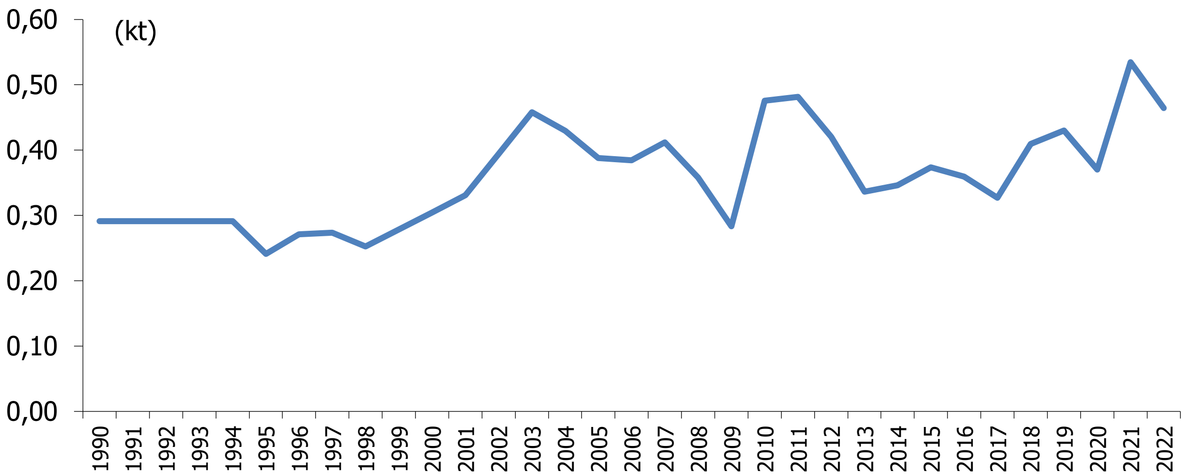
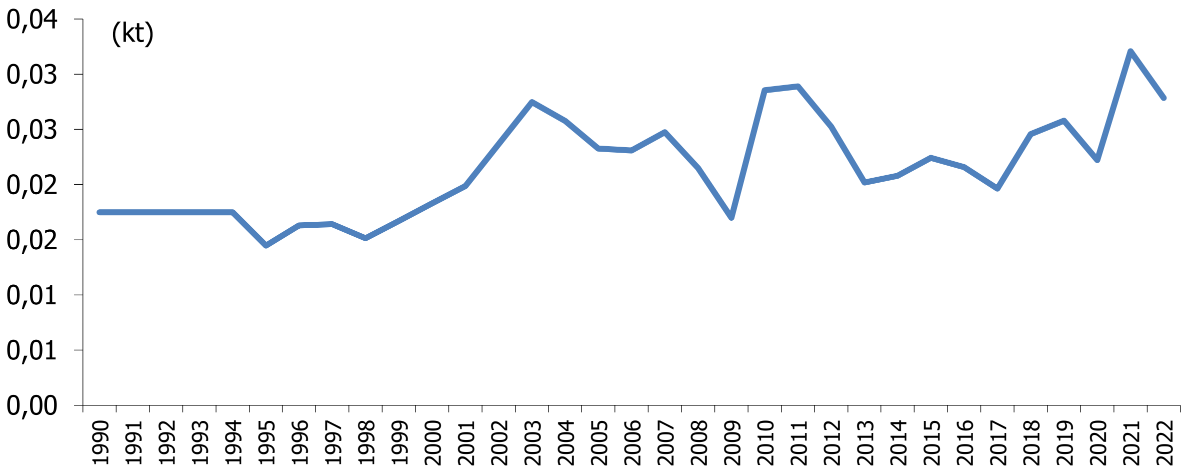


Figure 7.5 N_2O emissions from composting, 1990-2022



Uncertainties and Time-Series Consistency:

The uncertainty value for AD is estimated as 10.0% based on *Table 3.5 in the 2006 IPCC Guidelines, Volume 5, Chapter 3*. The uncertainty value of the EF is considered as 20.0% for both CH_4 and N_2O EFs since there is no sufficient information in 2006 IPCC.

The estimates are calculated in a consistent manner over time series.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

The data used in Biological Treatment of Solid Waste (CRT Category 5.B) are derived from waste statistics database of TurkStat. TurkStat is producing all its statistics according to the European Code of Practice Principles. Therefore, high quality data are used in the emission estimates of this category.

Recalculation:

Based on the ERT recommendation (ID#W.6) in the latest review (Report on the individual review of the inventory submission of Türkiye submitted in 2023), Türkiye differentiated between the amounts of MSW composted and treated in an MBT facility, and for the MSW treated in an MBT facility, quantified the fraction of waste that is composted and use only this fraction as AD to estimate emissions from composting. In this regard, the 1990-2021 time series has been recalculated and over the years, both methane and nitrous oxide emissions have changed in figures ranging from -7.6% to -48.6%.

Planned Improvement:

Emissions and amount of CH_4 for energy recovery from anaerobic digestion at biogas facilities (5.B.2) will be included in next inventory submissions depending on the availability of such treatment processes. Türkiye continues to monitor the available waste statistics and any other information to determine the existence of biogas facilities with anaerobic digestion. At this time, no such information exists, but when it becomes available, Türkiye intends to estimate these emissions.

7.4. Incineration and Open Burning of Waste (Category 5.C)

Source Category Description:

This category includes emissions from open burning of waste. The category covers CO_2, CH_4 and N_2O emissions from open burning of waste (5.C.2) which is divided into waste of biogenic origin (5.C.2.1) and waste of non-biogenic origin (5.C.2.2). Only municipal solid waste is open burned in Türkiye (5.C.2.2.a). CO_2 emissions from waste of biogenic origin are reported but not counted as part of the national total GHG emissions. Unlike CO_2, emissions of CH_4 and N_2O from biogenic derived wastes are estimated and accounted for under the waste sector.

Emissions from waste incineration (5.C.1) are included in the inventory but reported in the energy sector since the purpose of waste incineration is for energy recovery. Emissions from MSW of biogenic origin (5.C.1.1.a) and MSW of non-biogenic origin (5.C.1.2.a) are not occurring since MSW is not incinerated in the incineration plants in Türkiye.

Emissions from incineration of industrial solid waste of biogenic origin (5.C.1.1.b.i) and industrial solid waste of non-biogenic origin (5.C.1.2.b.i) are included in public electricity and heat production (1.A.1.a), chemicals (1.A.2.c) and other (1.A.2.g) sub-categories in the energy sector.

Emissions from incineration of clinical waste of biogenic origin (5.C.1.1.b.ii) and clinical waste of non-biogenic origin (5.C.1.2.b.ii) are included in public electricity and heat production (1.A.1.a).

Emissions from open burning of waste declined 89.3% (98.3 kt CO_2 eq.) between 1990 to 2022. The main reason of this negative trend is the decreasing amount of waste open-burned by years, especially with a sharp decline of emissions from open burning after 2014 after a regulation of Ministry of Environment, Urbanization and Climate Change (*Waste Management Regulation No. 29314 dated April 2, 2015).*

"(1) The purpose of this Regulation;

a) Ensuring the management of wastes from generation to disposal without harming the environment and human health,

b) Reducing the use of natural resources and ensuring waste management through ways such as reducing waste generation, reuse, recycling and recovery of wastes,

c) It is the determination of general procedures and principles regarding the production and market surveillance of products within the scope of this Regulation, which have certain criteria, basic conditions and characteristics in terms of environment and human health."

Before this regulation, the Ministry tightened the inspections and controls on waste management and then issued the regulation. With the implementation of the procedures and principles determined within the scope of this regulation, the amount of waste open burned has decreased.

Methodological Issues:

The IPCC Tier 2a method recommended in the 2006 IPCC Guidelines for National GHG Inventories is applied to estimate CO_2 emissions. As elaborated below, Türkiye multiplies the amount of waste types open-burned (wet weight) by the dry matter content, the fossil carbon fraction and an oxidation factor. To estimate CH_4 and N_2O emissions, IPCC default emission factors are multiplied by the amount of waste open-burned (the IPCC T1 method in the 2006 IPCC Guidelines).

CO_2 Emissions

The CO_2 emissions from open burning of waste are estimated on the basis of waste types/material (such as paper, wood, plastics) in the waste open-burned as given in *Equation 5.2 in the 2006 IPCC Guidelines, Volume 5, Chapter 5.*

$$CO_2\ Emissions = MSW \bullet \sum_j \left(WF_j \bullet dm_j \bullet CF_j \bullet FCF_j \bullet OF_j\right) \bullet 44/12$$

Where:

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

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

WF_j = fraction of waste type/material of component j in the MSW (as wet weight open-burned)

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

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

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

OF_j = oxidation factor, (fraction)

44/12 = conversion factor from C to CO_2

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

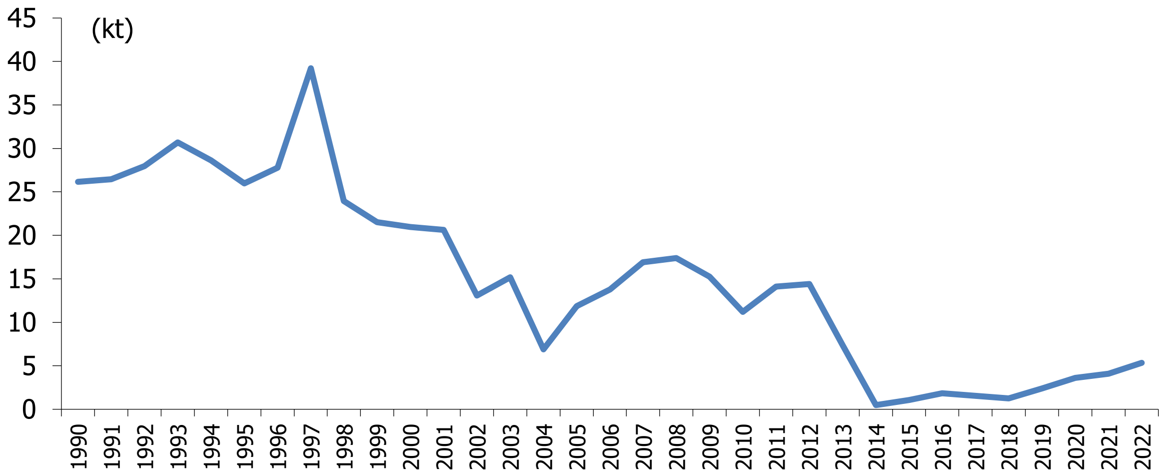
The biogenic CO_2 emissions from open burning should not be included in national total emission estimates according to the information given in *2006 IPCC, Volume 5, Chapter 5, Section 5.1* as in Table 7.25. Total CO_2 emissions from open burning fluctuate between 1990-2022 as shown in Figure 7.6.

Table 7.25 CO_2 emissions from open burning of waste, 1990-2022

(kt)

Year	Total	Biogenic	Non-biogenic
1990	26.14	0.283	26.14
1995	25.96	0.285	25.96
2000	20.98	0.345	20.98
2005	11.87	0.235	11.87
2010	11.21	0.142	11.21
2011	14.09	0.123	14.09
2012	14.42	0.088	14.42
2013	7.37	0.045	7.37
2014	0.48	0.003	0.48
2015	1.07	0.006	1.07
2016	1.84	0.011	1.84
2017	1.54	0.009	1.54
2018	1.24	0.006	1.24
2019	2.38	0.011	2.38
2020	3.62	0.017	3.62
2021	4.07	0.020	4.07
2022	5.35	0.024	5.35

Figure 7.6 CO_2 emissions from open burning of waste, 1990-2022



CH_4 Emissions

The calculation of CH_4 emissions is based on the amount of waste open-burned and on the related emission factor as given in *Equation 5.4 in the 2006 IPCC Guidelines, Volume 5, Chapter 5.*

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

Where:

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

IW_i = amount of solid waste of type i open-burned, Gg/yr

EF_i = aggregate CH4 emission factor, kg CH_4/Gg of waste

10^{-6} = conversion factor from kilogram to gigagram

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

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

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

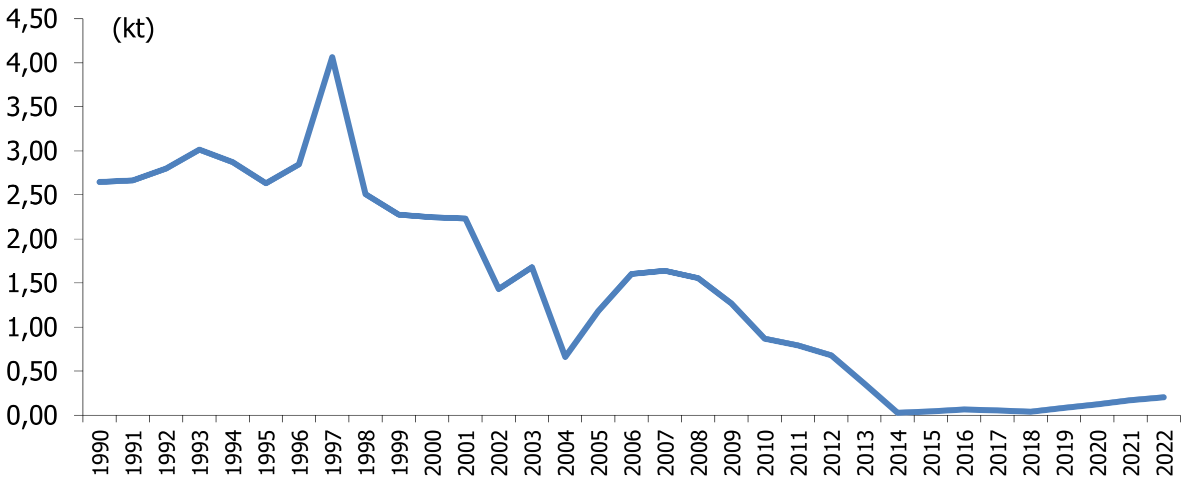
Estimated results of CH_4 emissions are given in Table 7.26 and Figure 7.7. The CH_4 emissions show a decreasing trend with the same fluctuations as with AD between 1990 and 2022 as can be seen in Figure 7.9 below.

Table 7.26 CH_4 emissions from open burning of waste, 1990-2022

(kt)

Year	Total	Biogenic	Non-biogenic
1990	2.65	1.78	0.87
1995	2.63	1.76	0.87
2000	2.25	1.39	0.85
2005	1.18	0.67	0.52
2010	0.87	0.52	0.35
2011	0.79	0.51	0.29
2012	0.68	0.46	0.22
2013	0.36	0.24	0.12
2014	0.03	0.02	0.01
2015	0.04	0.03	0.01
2016	0.07	0.05	0.02
2017	0.05	0.04	0.02
2018	0.04	0.03	0.01
2019	0.08	0.06	0.03
2020	0.12	0.08	0.04
2021	0.17	0.12	0.05
2022	0.20	0.13	0.07

Figure 7.7 CH_4 emissions from open burning of waste, 1990-2022



N_2O Emissions

The calculation of N_2O emissions is based on the amount of waste open-burned and a default emission factor as given in *Equation 5.5 in the 2006 IPCC Guidelines, Volume 5, Chapter 5.*

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

Where:

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

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

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

10^{-6} = conversion from kilogram to gigagram

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

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

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

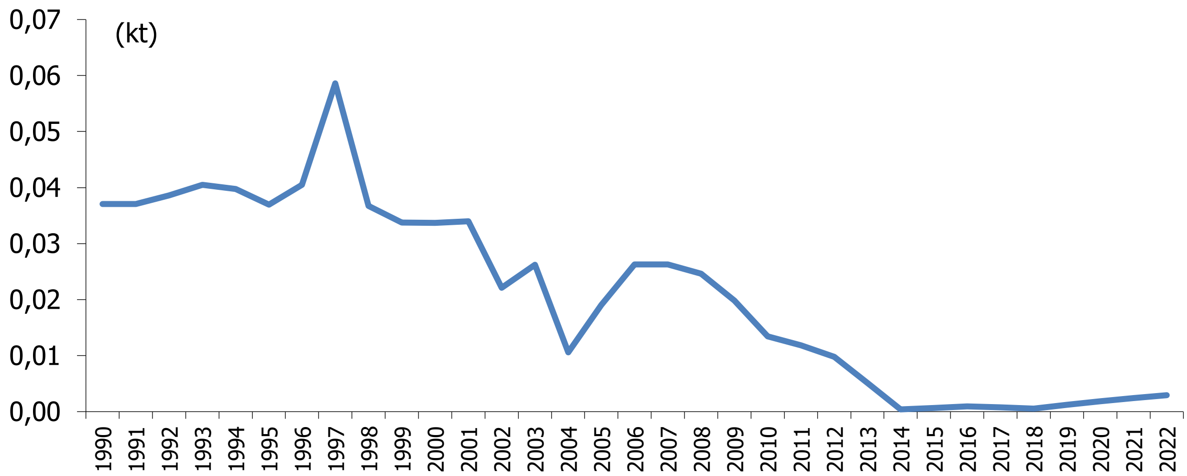
Estimated results of N_2O emissions from open burning of waste are given in Table 7.27 and Figure 7.8. As with CH_4 emissions, N_2O emissions have a decreasing trend with the same fluctuations as of AD between 1990 and 2022 as can be seen in Figure 7.9 below.

Table 7.27 N_2O emissions from open burning of waste, 1990-2022

(kt)

Year	Total	Biogenic	Non-biogenic
1990	0.0371	0.0188	0.0182
1995	0.0369	0.0187	0.0182
2000	0.0337	0.0158	0.0179
2005	0.0190	0.0082	0.0109
2010	0.0135	0.0060	0.0075
2011	0.0119	0.0057	0.0062
2012	0.0098	0.0050	0.0048
2013	0.0051	0.0026	0.0026
2014	0.0004	0.0002	0.0002
2015	0.0006	0.0003	0.0003
2016	0.0009	0.0005	0.0004
2017	0.0008	0.0004	0.0004
2018	0.0006	0.0003	0.0003
2019	0.0012	0.0006	0.0006
2020	0.0018	0.0009	0.0009
2021	0.0024	0.0013	0.0012
2022	0.0030	0.0015	0.0015

Figure 7.8 N_2O emissions from open burning of waste, 1990-2022



Collection of Activity Data

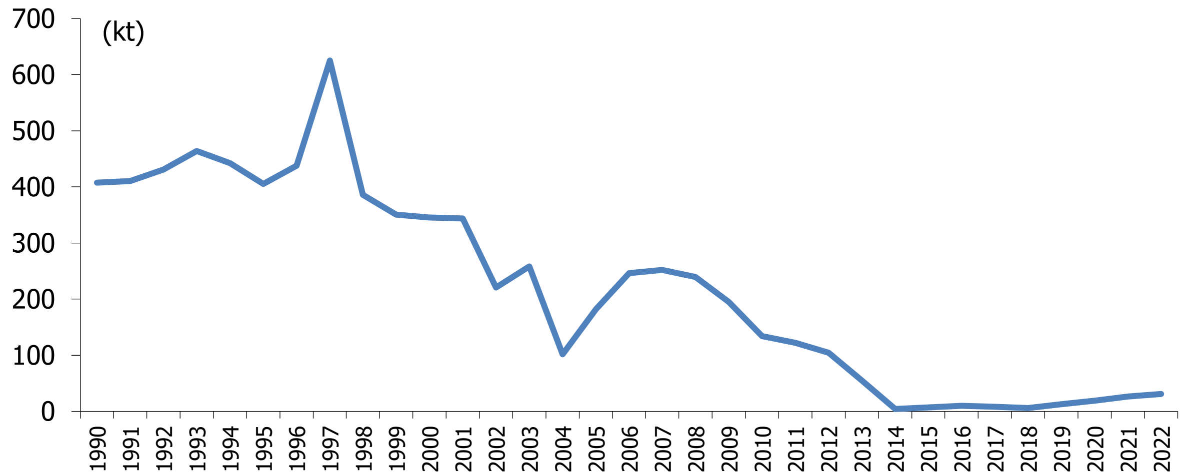
Activity data for open burning of MSW are estimated using the total amount of MSW open-burned (1994-1998, 2001-2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022) as obtained from TurkStat's *Municipal Waste Statistics Survey* as given in Table 7.5 and applying an estimate of the composition of MSW.

To calculate the total amount of MSW open-burned for the years not surveyed (1999, 2000, 2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019 and 2021) the total amount of MSW open-burned as a fraction of the MSW generated data is calculated for the available years (MSW generated data are given in Table 7.8). Open-burned % in generated MSW for the years 1999, 2000, 2005, 2007, 2009, 2011, 2013, 2015, 2017 and 2019 are estimated by linear interpolation. The open-burned % of 2021 (0.08%) has been recalculated by linear interpolation due to the availability of 2022 survey data. Due to lack of historical data for MSW open-burned, the open-burned % of 1994 (1.89%) is used for 1990-1993. As a result, the total amount of MSW open-burned is calculated for the entire time-series and provided in Table 7.28 and Figure 7.9.

Table 7.28 The fraction and amount of MSW open-burned, 1990-2022

Year	Fraction of MSW open-burned (%)	Amount of MSW open-burned (kt)
1990	1.89	407.25
1995	1.49	405.03
2000	1.13	345.52
2005	0.58	182.05
2010	0.45	133.88
2011	0.40	121.98
2012	0.34	104.75
2013	0.18	54.72
2014	0.01	4.28
2015	0.02	6.86
2016	0.03	10.17
2017	0.02	8.18
2018	0.02	6.13
2019	0.04	12.69
2020	0.05	19.02
2021	0.08	26.35
2022	0.10	31.05

Figure 7.9 Total amount of MSW open-burned, 1990-2022



Country-specific values on the total waste amount (Table 7.28) and the waste fraction for each component for MSW are needed to apply Tier 2a. To calculate the country-specific waste fraction, time series of MSW composition data (see Table 7.10) are used. Default dry matter content, total carbon content and fossil carbon fraction of different MSW components are given in Table 7.29 which is based on *Table 2.4 in the 2006 IPCC Guidelines, Volume 5, Chapter 2.*

Table 7.29 Default dry matter content, total carbon content and fossil carbon fraction (%)

MSW Component	Dry matter content in % of wet waste	Total carbon content in % of dry weight	Fossil carbon fraction in % of total carbon
Paper/cardboard	90.0	46.0	1.0
Textiles	80.0	50.0	20.0
Food waste	40.0	38.0	-
Wood	85.0	50.0	-
Garden and park waste	40.0	49.0	0.0
Plastics	100.0	75.0	100.0
Metal	100.0	NA	NA
Glass	100.0	NA	NA
Other, inert waste	90.0	3.0	100.0

Choice of Emission Factor

Dry matter content (dm), total carbon content (CF) and fossil carbon fraction (FCF) in MSW are calculated using *Equations 5.8, 5.9 and 5.10* respectively as given in the *2006 IPCC Guidelines, Volume 5, Chapter 5.* All different waste fractions (WF) are given in Table 7.10 and the fractions of carbon content given in Table 7.29 above are used related to CO_2 emission factors. A default oxidation factor in % of carbon input (OF) is selected for MSW as 58.0% based on *Table 5.2 in 2006 IPCC, Volume 5, Chapter 5*.

The CH_4 emissions from open burning of waste are estimated using an EF of 6500 g CH_4 / t wet weight for both biogenic and non-biogenic origin of MSW as reported in the *2006 IPCC Guidelines, Volume 5, Chapter 5, Section 5.4.2*.

The N_2O emissions from open burning of waste are estimated using an EF of 150 g N_2O / t dry weight for MSW according to the *2006 IPCC Guidelines, Volume 5, Chapter 5, Table 5.6.* Since the related EF refers to dry weight, the weight of waste open-burned is converted from wet weight to dry weight as reported in the *2006 IPCC Guidelines, Volume 5, Chapter 5, Section 5.3.3* for MSW of both biogenic and non-biogenic origin.

Uncertainties and Time-Series Consistency:

The uncertainty value for AD is estimated as 30.4%. The uncertainty value of the CO_2 EF is considered as 40.0%. Since default values for CH_4 and N_2O EFs are used, the uncertainty values of ± 100% are estimated for both EFs as recommended in the *2006 IPCC Guidelines, Volume 5, Chapter 5, Section 5.7.1.*

The estimates are calculated in a consistent manner over time series.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

The data used in Incineration and Open Burning of Waste (CRT Category 5.C) are derived from the waste statistics database of TurkStat. TurkStat is producing all its statistics according to the European Code of Practice Principles. Therefore, high quality data are used in the emission estimates of this category.

Recalculation:

2021 data for the fraction of MSW open-burned has been recalculated by linear interpolation due to availability of 2022 survey data from TurkStat's *Municipal Waste Statistics Survey*. As stated in the "Recalculation" section of Category 5.A above; 2021 waste composition data was revised with the acquisition of survey data. Therefore, Category 5.C emission estimations for 2021 were also affected by this recalculation. Due to this recalculation, carbon dioxide emissions have changed 11.6%, methane emissions have changed 37.5% and nitrous oxide emissions have changed 31.8%.

The amount of waste generated for the years 1990-1993 has been revised as a consequence of the recalculation based on the ERT recommendation (ID#W.5) in the latest review (Report on the individual review of the inventory submission of Türkiye submitted in 2023). This has also affected the amount of open burning waste for the same years. Due to this recalculation, both methane and nitrous oxide emissions have changed in figures ranging from -2.6% to 6.6%.

Planned Improvement:

There are no planned improvements in this category.

7.5. Wastewater Treatment and Discharge (Category 5.D)

Source Category Description:

This category includes CH_4 and N_2O emissions from wastewater treatment and discharge systems. Wastewater originates from domestic, commercial and industrial sources by treatment and disposal systems. Because of the IPCC methodology, emissions from commercial wastewater are estimated as part of domestic wastewater. Treatment and disposal types for domestic and industrial wastewater are separated into collected and uncollected systems. Each system is divided into untreated and treated systems. For collected systems; sea, river and lake discharge, and stagnant sewer are the untreated systems. Aerobic and anaerobic treatments are the main treated systems of sewered to plants. For uncollected systems; septic system is considered as treated and sea, river and lake discharge as untreated practices in Türkiye.

CH_4 emissions are estimated for both domestic wastewater (5.D.1) and industrial wastewater (5.D.2). N_2O emissions from 5.D.2 are also reported in 5.D.1.

Wastewater treatment and discharge emissions increased by 27.6% (1 215 kt CO_2 eq.) for the period 1990-2022, also increased by 2.8% (151 kt CO_2 eq.) between 2021 and 2022. Methane recovery in domestic wastewater treatment increased by 373% (573 kt CO_2 eq.) between 1998 (154 kt CO_2 eq.) and 2022 (726 kt CO_2 eq.).

Methodological Issues:

Methane Emissions from Wastewater

Methane Emissions from Domestic Wastewater

The IPCC T2 method of the 2006 IPCC Guidelines is applied to estimate CH_4 emissions from domestic wastewater. CH_4 emissions are estimated using *Equation 6.1 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$CH_4\ Emissions = \left[\sum_{i,j}\left(U_i \bullet T_{i,j} \bullet EF_j\right)\right](TOW - S) - R$$

Where:

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

TOW = total organics in wastewater in inventory year, kg BOD/yr

S = organic component removed as sludge in inventory year, kg BOD/yr

U_i = fraction of population in income group in inventory year

$T_{i,j}$= degree of utilization of treatment/discharge pathway or system, j, for each income group fraction in inventory year

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

j = each treatment/discharge pathway or system

EF_j = emission factor, kg CH_4 / kg BOD

R = amount of CH_4 recovered in inventory year, kg CH_4/yr

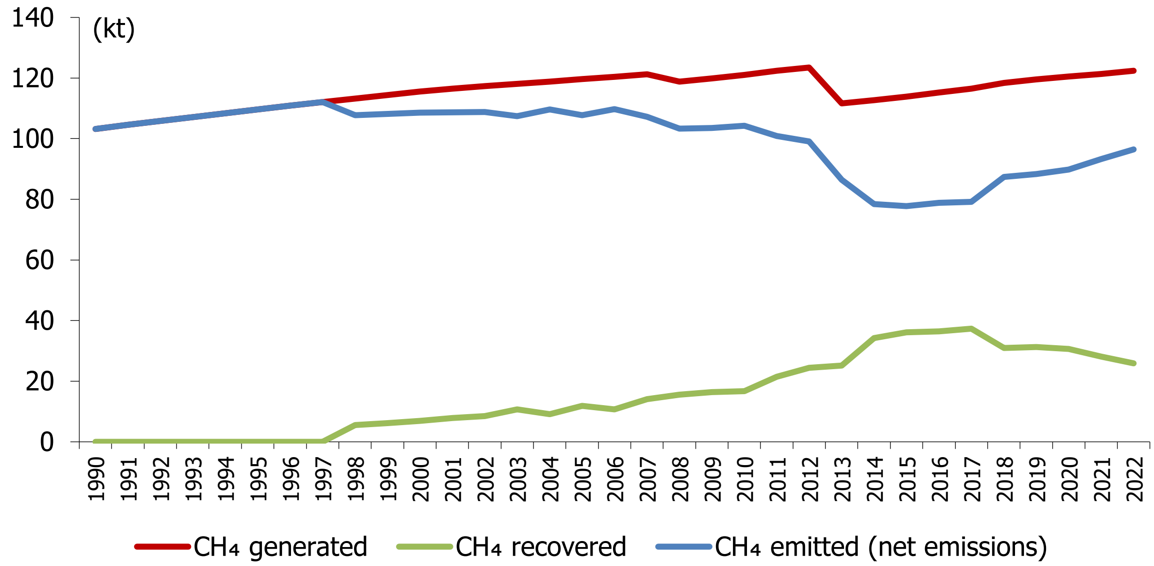
Total CH_4 emissions are estimated based on country-specific information on the total organics in wastewater minus the total amount of sludge and multiplying by the IPCC default emission factor, corrected for country-specific fractions of urban/rural populations and the fraction of the wastewater utilizing the various discharge pathways. The amount of methane generated, methane recovered and net methane emissions are estimated as given in Table 7.30 and Figure 7.10.

Table 7.30 CH_4 generated, recovered and emitted from domestic wastewater, 1990-2022

(kt)

Year	CH_4 Generated	CH_4 Recovered	CH_4 Emitted
1990	103.2	NO	103.2
1995	109.7	NO	109.7
2000	115.6	6.9	108.6
2005	119.6	11.9	107.7
2010	121.1	16.8	104.3
2011	122.4	21.5	100.9
2012	123.5	24.4	99.0
2013	111.6	25.1	86.5
2014	112.7	34.3	78.5
2015	113.9	36.1	77.8
2016	115.2	36.4	78.8
2017	116.5	37.3	79.2
2018	118.4	31.0	87.4
2019	119.5	31.2	88.3
2020	120.5	30.7	89.8
2021	121.4	28.1	93.3
2022	122.4	25.9	96.5

Figure 7.10 CH_4 emissions from domestic wastewater, 1990-2022



The key drivers for the decreasing trend in net emissions are the increasing recovery of methane after the beginning year of 1998. Despite an increasing trend normally, the main reasons for the sharp decreases in generated methane in the years of 2008 and 2013 are the administrative division changes in the proportion of urban and rural population in 2008 and 2013.

Collection of Activity Data

To calculate CH_4 emissions from domestic wastewater, total organics in wastewater (TOW) and organic component removed as sludge (S) are needed. The TOW is calculated using *Equation 6.3 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$TOW = P \bullet BOD \bullet 0.001 \bullet I \bullet 365$$

Where:

TOW = total organics in wastewater in inventory year, kg BOD/yr

P = country population in inventory year, (person)

BOD = country-specific per capita BOD in inventory year, g/person/day,

0.001 = conversion from grams BOD to kg BOD

I = correction factor for additional industrial BOD discharged into sewers (for collected the default is 1.25, for uncollected the default is 1.00.)

The total population is used to calculate TOW and S values. For the entire time series, the total population is taken from Turkstat's *Mid-year Population Estimations and Projections*. The total population is then divided into the rural and urban fractions to better characterize the discharge pathways for the domestic wastewater. For the years 1990 and 2000, rural and urban population are available from *General Population Censuses*. The results of *Address Based Population Registration System* are used from 2007 to 2022 to split the rural and urban population. Rural and urban population fractions are used to interpolate fractions of rural and urban population for the missing years. The figures are given in Table 7.31.

Table 7.31 Fraction of population and total, rural, urban population, 1990-2022

Year	Fraction of rural	Fraction of urban	Total population	Rural population	Urban population
1990	41.0	59.0	55 120 000	22 592 114	32 527 886
1995	38.0	62.0	59 756 000	22 732 684	37 023 316
2000	35.1	64.9	64 269 000	22 557 058	41 711 942
2005	31.1	68.9	68 435 000	21 293 571	47 141 429
2010	23.7	76.3	73 142 000	17 362 715	55 779 285
2011	23.2	76.8	74 224 000	17 222 484	57 001 516
2012	22.7	77.3	75 176 000	17 076 420	58 099 580
2013	8.7	91.3	76 148 000	6 588 471	69 559 529
2014	8.2	91.8	77 182 000	6 367 326	70 814 674
2015	7.9	92.1	78 218 000	6 176 615	72 041 385
2016	7.7	92.3	79 278 000	6 101 802	73 176 198
2017	7.5	92.5	80 313 000	6 012 149	74 300 851
2018	7.7	92.3	81 407 000	6 291 257	75 115 743
2019	7.2	92.8	82 579 000	5 962 131	76 616 869
2020	7.0	93.0	83 385 000	5 862 196	77 522 804
2021	6.8	93.2	84 147 000	5 735 295	78 411 705
2022	6.6	93.4	84 980 000	5 646 371	79 333 629

The urban population consists of the total population of province and district centers and, rural population consists of the total population of towns and villages. The proportions of the population living in the province and district centers were 91.3% in 2013 and 93.4% in 2022 while this figure was 77.3% in 2012. The main reason for this sharp rise was the establishment of 14 new metropolitan municipalities and enlarging the municipal borders by abolition of towns and villages in all of the 30 metropolitan provinces in 2013.

TOW is calculated using a country-specific per capita BOD as 53 g/person/day for wastewater collected by sewers. The source of this BOD is *Derivation of Factors for Pollution Loads Discharged to Receiving Bodies by Municipalities, İpek Turtin Uzer, Turkish Statistical Institute Expertness Thesis, Ankara, 2010*. This study includes a country-specific per capita BOD for receiving bodies as 25 g/person/day. Country-specific per capita BOD for sludge removed is calculated as 28 g/person/day by using these data to be able to calculate organic component removed as sludge (S). The CS-per capita BOD already includes the additional industrial discharge. TOW and S values for domestic wastewater are calculated as given in Table 7.32.

Table 7.32 Total organics in wastewater (TOW) and organic component removed as sludge (S) for domestic wastewater, 1990-2022

(kt BOD/yr)

Year	TOW	S
1990	1 066.3	563.3
1995	1 156.0	610.7
2000	1 243.3	656.8
2005	1 323.9	699.4
2010	1 414.9	747.5
2011	1 435.9	758.6
2012	1 454.3	768.3
2013	1 473.1	778.2
2014	1 493.1	788.8
2015	1 513.1	799.4
2016	1 533.6	810.2
2017	1 553.7	820.8
2018	1 574.8	832.0
2019	1 597.5	844.0
2020	1 613.1	852.2
2021	1 627.8	860.0
2022	1 643.9	868.5

Choice of Emission Factor

As given in *Equation 6.2 in the 2006 IPCC Guidelines, Volume 5, Chapter 6*, CH_4 EFs for each domestic wastewater treatment/discharge pathway or system are calculated by multiplying the default maximum CH_4 producing capacity (B_o) for domestic wastewater (0.6 kg CH_4/kg BOD) by the methane correction factor (MCF) for each type of treatment and discharge pathway or system, which is given in the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.3*.

$$EF_j = B_o \bullet MCF_j$$

Where:

EF_j = emission factor, kg CH_4/kg BOD

j = each treatment/discharge pathway or system

B_o = maximum CH_4 producing capacity, kg CH_4/kg BOD

MCF_j = methane correction factor (fraction)

To calculate country-specific values for the degrees of treatment utilization (T), by population class, the results of TurkStat's *Municipal Wastewater Statistics Survey, 2012* and *Sectoral Water and Wastewater Statistics Survey, 2012* are used. The degrees of utilizations are given in Table 7.33.

Table 7.33 Degrees of treatment utilization (T) by population class

Treatment or discharge system or pathway		T (%)
Rural	To sea, river and lake	0.43
	To aerobic plant, not well managed	0.44
	To septic systems	10.72
Urban	To sea, river and lake	15.43
	To aerobic plant, well managed	44.01
	To aerobic plant, not well managed	1.82
	To anaerobic digester for sludge	20.83
	To septic systems	6.31
Total		100.00

Weighted CH_4 EFs are calculated using CH_4 EFs by each type of treatment and discharge pathway or system and the fractional usage of different treatment systems by population class. Weighted CH_4 EFs for domestic wastewater with background data are given in Table 7.34.

Table 7.34 MCF, EFs, utilization degrees and weighted EFs by population class

Type of treatment and discharge path way or system	MCF	CH_4 EF	T (Rural)	T (Urban)
Untreated system				
Sea, river, lake discharge	0.10	0.06	0.0043	0.1543
Treated system				
Centralized, aerobic, well managed	0.00	0.00		0.4401
Centralized, aerobic, not well managed	0.30	0.18	0.0044	0.0182
Anaerobic digester for sludge	0.80	0.48		0.2083
Septic system	0.50	0.30	0.1072	0.0631
Total			**0.12**	**0.88**
Weighted CH_4 EFs (kg CH_4/kg BOD)			**0.29**	**0.15**

Methane Recovery

The recovery of methane and its subsequent utilization are also included in the inventory. The recovery of methane from biogas commenced in Türkiye in 1998. Therefore, the quantity of recovered methane is subtracted from the methane produced beginning in the year 1998. In 2013, *Municipal Wastewater Statistics Survey, 2012* was applied to all municipalities. Based on the information obtained from the survey, TurkStat sends official letters to each facility recovering methane for requesting the quantity of methane gas and electricity/heat production for the entire operating period of the facility every year. The facilities estimate the quantity of methane recovered by measuring of gas recovered. The obtained information on the quantity of produced electricity/heat is used for cross-checking the quantity of methane recovered.

The coverage of the facilities is followed and updated depending on availability of new information; such as information obtained from the facility, the information from the most recent (biennial) survey *(i.e. Municipal Wastewater Statistics Survey, 2022)*. The emissions of energy production from the recovered CH_4 gas in biogas facilities were included in the category of Public Electricity and Heat Production (1.A.1.a).

The number of biogas facilities in wastewater treatment plants and the amount of recovered methane by year are given in Table 7.35.

Table 7.35 Methane recovery, 1990-2022

Year	Number of biogas facilities	Recovered methane (kt)
1990-97	NA	NO
1998	1	5.5
1999	1	6.2
2000	1	6.9
2005	4	11.9
2010	8	16.8
2011	13	21.5
2012	14	24.4
2013	18	25.1
2014	19	34.3
2015	20	36.1
2016	23	36.4
2017	23	37.3
2018	27	31.0
2019	26	31.2
2020	25	30.7
2021	22	28.1
2022	21	25.9

Sewage Sludge Balance

Sewage sludge is domestic wastewater treatment sludge originating from urban wastewater treatment plants operated by municipalities. Thus, the sewage sludge data are collected by TurkStat from Municipal Wastewater Statistics Survey which is applied to all municipalities. Data on the amount of sludge is compiled on a wet basis and converted to dry matter using coefficients in the guidance documents of the European Union Statistical Office (EUROSTAT). Also, data are compiled in accordance with the OECD / EUROSTAT - Wastewater statistics, environmental data and indicators data set.

As mentioned in Solid Waste Disposal section (Category 5.A), the disposal methods named 'Dumping onto land', 'Municipal dumping sites', 'Controlled landfill sites', 'Buried' and 'Other disposal' are added together and assumed as the total sludge that stored in SWDS.

For the sewage sludge balance, the amount of sewage sludge by disposal and recovery methods, please refer to Table 7.36.

Table 7.36 Amount of sewage sludge by disposal and recovery methods, 1994-2022 (1)

(t)

Year	Agricultural use	Released into sea	Dumping onto land	Municipal dumping sites	Released into lake	Released into river	Incineration with energy recovery	Controlled landfill sites	Buried	Other disposal(2)	Other recovery(3)
1994	12 546	321	0	1 494	0	0	0	0	0	26	0
1995	13 309	10	150	1 783	0	0	0	0	0	56	0
1996	12 322	0	40	1 931	0	0	0	20	10	2	0
1997	34 397	0	0	1 871	0	0	0	26	2	112	0
1998	49 555	0	2 029	10 125	297	0	0	6 627	487	0	0
2001	47 152	54	45	28 356	50	7 300	0	40 431	1 500	467	0
2002	26 445	1 095	274	31 189	4	0	1	55 789	8 378	37 560	0
2003	91 104	0	521	13 218	180	0	0	57 518	10 302	0	0
2004	81 795	0	2 760	12 345	48	1 000	0	92 085	2 154	36 128	0
2006	12 512	0	2 954	65 044	20 000	2 161	0	85 606	38 281	31 772	0
2008	17 118	0	9 480	58 026	0	3 074	2 082	104 846	12 890	67 350	0
2010	12 433	0	10 112	92 741	0	2 018	13 020	98 843	10 243	71 402	0
2012	11 412	0	19 456	107 989	0	22	29 952	101 143	2 517	45 906	0
2014	10 255	0	39 637	41 214	0	105	53 486	91 539	4 670	46 884	0
2016	9 261	0	7 023	62 733	0	0	93 939	83 005	278	43 057	0
2018	10 349	0	6 710	36 135	5	10	143 494	85 382	4 464	31 932	23
2020	3 423	0	14 460	38 971	0	1 040	135 782	75 571	207	29 561	15 310
2022	19 730	0	9 810	51 034	0	20	132 963	65 313	92	31 767	37 309

Source: TurkStat, Municipal Wastewater Statistics

(1) Data on sludge amount is in dry matter.

(2) Includes other disposal operations, temporary storage, land treatment, surface impoundment etc.

(3) Includes other recovery operations.

Methane Emissions from Industrial Wastewater

This section deals with estimating CH_4 emissions from on-site industrial wastewater treatment. The IPCC T2 method of the 2006 IPCC Guidelines is applied to estimate CH_4 emissions from industrial wastewater. CH_4 emissions are estimated using *Equation 6.4 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$CH_4\ Emissions = \sum_i [(TOW_i - S_i)\ EF_i - R_i]$$

Where:

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

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

i = industrial sector

S_i = organic component removed as sludge in inventory year, kg COD/yr

EF_i = emission factor for industry i, kg CH_4/kg COD

for treatment/discharge pathway or system(s) used in inventory year

R_i = amount of CH_4 recovered in inventory year, kg CH_4/yr

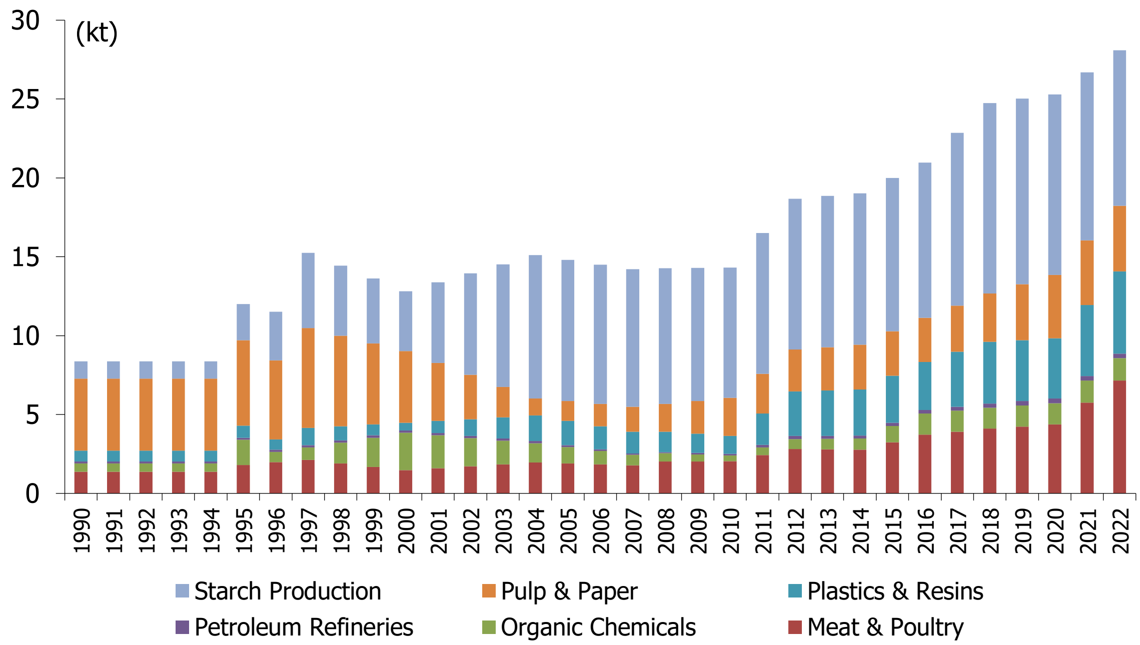
Specifically, the country-specific information on the total organically degradable material in wastewater, by industry, is multiplied by a specific emission factor that takes into account the relative use of various treatment/discharge pathways. There is no recovery of methane from industrial wastewater and sludge removal is assumed to be zero. Amount of methane emissions, by industry, are estimated as given in Table 7.37 and Figure 7.11.

Table 7.37 CH_4 emissions from industrial wastewater by sector, 1990-2022

(kt)

Year	Total	Meat & poultry	Organic chemicals	Petroleum refineries	Plastics & resins	Pulp & paper (combined)	Starch production
1990-94	8.37	1.37	0.54	0.12	0.70	4.56	1.09
1995	12.01	1.79	1.62	0.12	0.75	5.43	2.29
2000	12.82	1.47	2.38	0.15	0.48	4.55	3.80
2005	14.80	1.90	1.03	0.13	1.54	1.25	8.96
2010	14.32	2.03	0.36	0.11	1.14	2.41	8.26
2011	16.50	2.42	0.50	0.15	1.99	2.52	8.91
2012	18.68	2.81	0.63	0.19	2.84	2.64	9.57
2013	18.85	2.79	0.67	0.19	2.88	2.74	9.58
2014	19.02	2.76	0.71	0.19	2.92	2.85	9.60
2015	20.00	3.24	1.03	0.20	2.98	2.82	9.72
2016	20.97	3.72	1.34	0.22	3.05	2.79	9.84
2017	22.86	3.91	1.34	0.24	3.49	2.93	10.96
2018	24.75	4.10	1.34	0.25	3.93	3.06	12.07
2019	25.02	4.23	1.34	0.28	3.86	3.54	11.76
2020	25.29	4.37	1.35	0.30	3.80	4.02	11.45
2021	26.70	5.76	1.38	0.30	4.50	4.09	10.66
2022	28.10	7.16	1.41	0.30	5.20	4.16	9.87

Figure 7.11 CH_4 emissions from industrial wastewater, 1990-2022



Collection of Activity Data

To calculate CH_4 emissions from industrial wastewater, total organically degradable material in wastewater for each industry (TOW_i) is used as AD and calculated by applying *Equation 6.6 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$TOW_i = P_i \bullet W_i \bullet COD_i$$

Where:

TOW_i = total organically degradable material in wastewater for industry i, kg COD/yr

i = industrial sector

P_i = total industrial product for industrial sector i, t/yr

W_i = wastewater generated, $m^3/t_{product}$

COD_i = chemical oxygen demand (industrial degradable organic component in wastewater), kg COD/m^3

Organic component removed as sludge (S) is assumed to be zero in the inventory years. The amount of industrial wastewater treated for the following major industrial sectors are obtained from TurkStat's *Manufacturing Industry Establishments Water, Wastewater and Waste Statistics Survey* for the years 1994-1997, 2000, 2004, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022. Missing data for the years not surveyed (1998, 1999, 2001-2003, 2005-2007, 2009, 2011, 2013, 2015, 2017 and 2019) are estimated by linear interpolation. 2021 AD of previous submission has been recalculated by interpolation method due to availability of 2022 AD.

The amount of industrial wastewater treated by industrial sectors are given in Table 7.38.

Table 7.38 Amount of industrial wastewater discharged by sector, 1990-2022

(thousand m^3/yr)

Year	Total	Meat & poultry	Organic chemicals	Petroleum refineries	Plastics & resins	Pulp & paper (combined)	Starch production
1990-94	110 753	25 749	13 771	9 155	14 574	39 072	8 432
1995	164 593	33 752	41 583	9 239	15 739	46 583	17 697
2000	178 484	27 591	61 139	11 423	10 014	39 011	29 306
2005	184 002	35 758	26 501	9 728	32 198	10 691	69 127
2010	164 314	38 282	9 372	8 421	23 862	20 628	63 750
2011	201 980	45 624	12 791	11 620	41 503	21 649	68 792
2012	239 646	52 967	16 211	14 819	59 145	22 670	73 834
2013	241 879	52 494	17 277	14 636	59 995	23 535	73 944
2014	244 112	52 020	18 342	14 452	60 844	24 399	74 054
2015	264 574	61 040	26 429	15 670	62 250	24 180	75 005
2016	285 035	70 059	34 516	16 887	63 655	23 961	75 956
2017	308 713	73 634	34 434	18 197	72 778	25 115	84 556
2018	332 391	77 208	34 351	19 507	81 901	26 268	93 156
2019	337 462	79 707	34 544	21 490	80 607	30 364	90 750
2020	342 533	82 205	34 738	23 474	79 312	34 460	88 345
2021	378 426	108 457	35 566	23 148	93 928	35 052	82 275
2022	414 319	134 709	36 395	22 822	108 543	35 644	76 206

TOW_i is calculated by applying COD values for each industrial sector as given in Table 7.39, that are based on *Table 6.9 in the 2006 IPCC Guidelines, Volume 5, Chapter 6* and the results are given in Table 7.40.

Table 7.39 COD values by industry type

Industry type	COD (kg/m^3)
Meat & Poultry	4.1
Organic Chemicals	3.0
Petroleum Refineries	1.0
Plastics & Resins	3.7
Pulp & Paper (combined)	9.0
Starch Production	10.0

Table 7.40 TOW_i in wastewater by industry sector, 1990-2022

(kt COD/yr)

Year	Total	Meat & poultry	Organic chemicals	Petroleum refineries	Plastics & resins	Pulp & paper (combined)	Starch production
1990-94	645.9	105.6	41.3	9.2	53.9	351.6	84.3
1995	926.8	138.4	124.7	9.2	58.2	419.2	177.0
2000	989.2	113.1	183.4	11.4	37.1	351.1	293.1
2005	1 142.5	146.6	79.5	9.7	119.1	96.2	691.3
2010	1 104.9	157.0	28.1	8.4	88.3	185.7	637.5
2011	1 273.4	187.1	38.4	11.6	153.6	194.8	687.9
2012	1 441.8	217.2	48.6	14.8	218.8	204.0	738.3
2013	1 454.9	215.2	51.8	14.6	222.0	211.8	739.4
2014	1 468.0	213.3	55.0	14.5	225.1	219.6	740.5
2015	1 543.2	250.3	79.3	15.7	230.3	217.6	750.1
2016	1 618.4	287.2	103.5	16.9	235.5	215.7	759.6
2017	1 764.3	301.9	103.3	18.2	269.3	226.0	845.6
2018	1 910.1	316.6	103.1	19.5	303.0	236.4	931.6
2019	1 930.9	326.8	103.6	21.5	298.2	273.3	907.5
2020	1 951.8	337.0	104.2	23.5	293.5	310.1	883.4
2021	2 060.3	444.7	106.7	23.1	347.5	315.5	822.8
2022	2 168.8	552.3	109.2	22.8	401.6	320.8	762.1

Choice of Emission Factor

As given in *Equation 6.5 in the 2006 IPCC Guidelines, Volume 5, Chapter 6*, CH_4 EFs for each industrial wastewater treatment/discharge pathway or system are calculated by multiplying the default maximum

CH_4 producing capacity (B_o) for industrial wastewater (0.25 kg CH_4/kg COD) by the methane correction factor (MCF) for each type of treatment and discharge pathway or system which is given in the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.8.*,

$$EF_j = B_o \bullet MCF_j$$

Where:

EF_j = emission factor for each treatment/discharge pathway or system, kg CH_4/kg COD,

j = each treatment/discharge pathway or system

B_o = maximum CH_4 producing capacity, kg CH_4/kg COD

MCF_j = methane correction factor (fraction)

Weighted CH_4 EFs are calculated by multiplying CH_4 EFs for each type of treatment and discharge pathway or system and fractional usage of the different treatment systems. Weighted CH_4 EF for industrial wastewater with background data are given in Table 7.41.

Table 7.41 MCF, EFs, fractional usages and weighted EF for industrial wastewater

Type of treatment and discharge pathway or system	MCF	CH_4 EF	Fractional usage
Untreated system			
Sea, river, lake discharge	0.10	0.03	0.173
Treated system			
Aerobic treatment plant, well managed	0.00	0.00	0.668
Aerobic treatment plant, not well managed	0.30	0.08	0.088
Anaerobic digester for sludge	0.80	0.20	0.025
Anaerobic reactor	0.80	0.20	0.030
Septic system	0.50	0.13	0.016
Total			**1.00**
Weighted CH_4 EF (kg CH_4/kg COD)			**0.01**

Nitrous Oxide Emissions from Wastewater

Türkiye applies the default method from the 2006 IPCC Guidelines to estimate N_2O emissions from domestic wastewater. N_2O emissions from domestic wastewater effluent are estimated using *Equation 6.7 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.* Specifically, N_2O emissions are assumed to equal the amount of nitrogen discharged to aquatic environments, multiplied by an emission factor.

$$N_2O\ Emissions = N_{EFFLUENT} \bullet EF_{EFFLUENT} \bullet 44/28$$

Where:

N_2O emissions = N_2O emissions in inventory year, kg N_2O/yr

$N_{EFFLUENT}$ = nitrogen in the effluent discharged to aquatic environments, kg N/yr

$EF_{EFFLUENT}$ = emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N

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

N_2O emissions from centralized wastewater treatment plants with nitrification and denitrification steps are also taken into account by subtracting the amount of nitrogen associated with N_2O emissions from these plants from the total nitrogen discharged in the wastewater effluent. N_2O emissions from such plants are estimated using *Equation 6.9 in 2006 IPCC, Volume 5, Chapter 6.*

$$N_2O_{PLANTS} = P \bullet T_{PLANT} \bullet F_{IND-COM} \bullet EF_{PLANT}$$

Where:

N_2O_{PLANTS} = total N_2O emissions from plants in inventory year, kg N_2O/yr

P = human population

T_{PLANT} = degree of utilization of modern, centralized WWT plants, %

$F_{IND-COM}$ = fraction of industrial and commercial co-discharged protein (default = 1.25),

EF_{PLANT} = emission factor, 3.2 g N_2O/person/year

The estimation results are given in Table 7.42. As can be seen in Figure 7.12, total N_2O emissions increased by 66.4% from 1990 to 2022. N_2O emissions from centralized WWT plants for 1990-2000 period are reported as "NO" because the nitrogen removal is not available before 2001. T_{PLANT} values for 2001-2022 are reported in CRT table 5.D, under additional information.

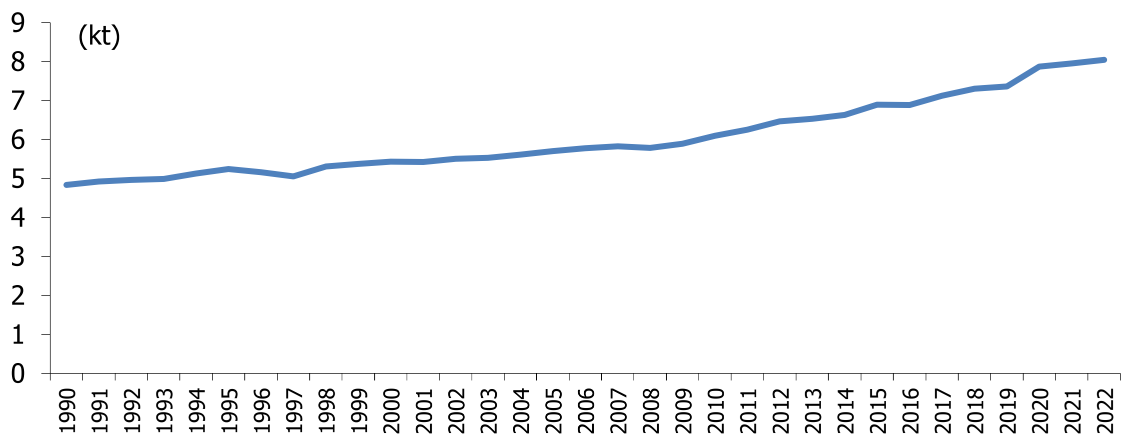
Türkiye reports N_2O emissions from industrial wastewater as "IE" in CRT table 5.D. As discussed further below, N_2O emissions from industrial wastewater (category 5.D.2) discharged into sewers is included in the N_2O emissions from domestic wastewater (category 5.D.1).

Table 7.42 N_2O emissions from wastewater, 1990-2022

(kt)

Year	N_2O emissions from wastewater effluent	N_2O emissions from centralized WWT plants	Total N_2O emissions
1990	4.84	NO	4.84
1995	5.24	NO	5.24
2000	5.44	NO	5.44
2005	5.68	0.03	5.71
2010	6.02	0.08	6.10
2011	6.17	0.08	6.25
2012	6.39	0.08	6.47
2013	6.45	0.09	6.54
2014	6.54	0.10	6.64
2015	6.78	0.11	6.89
2016	6.77	0.11	6.89
2017	7.00	0.12	7.13
2018	7.17	0.13	7.31
2019	7.23	0.14	7.36
2020	7.74	0.14	7.88
2021	7.82	0.14	7.96
2022	7.90	0.14	8.04

Figure 7.12 N_2O emissions from wastewater, 1990-2022



Collection of Activity Data

The activity data that are needed for estimating N_2O emissions are nitrogen content in the wastewater effluent, country population and average annual per capita protein generation (kg/person/yr).

The total nitrogen in the effluent is estimated using *Equation 6.8 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$N_{EFFLUENT} = (P \bullet Protein \bullet {}_{NPR} \bullet F_{NON-CON} \bullet F_{IND-COM}) - N_{SLUDGE}$$

Where:

$N_{EFFLUENT}$ = total annual amount of nitrogen in the wastewater effluent, kg N/yr

P = human population

Protein = annual per capita protein consumption, kg/person/yr

F_{NPR} = fraction of nitrogen in protein, kg N/kg protein

$F_{NON\text{-}CON}$ = factor for non-consumed protein added to the wastewater

$F_{IND\text{-}COM}$ = factor for industrial and commercial co-discharged protein into the sewer system

N_{SLUDGE}= nitrogen removed with sludge, kg N/yr

Per capita protein consumption in Türkiye has been obtained from the FAOSTAT's website *(http://www.fao.org/faostat/en/#data/FBS/visualize).* The link has re-checked for up-to-date data of recent years, and it is found that the new Food Balances are available after 2010. 2010-2021 data have been updated on the link. These revised data are used instead of the data in the previous submission. 2022 data is extrapolated due to lack of data.

Population and annual per capita protein consumption data are given in Table 7.43.

Table 7.43 Population and per capita protein consumption, 1990-2022

Year	Population (1) (1000's persons)	Per capita protein consumption (2) (kg/person/yr)
1990	55 120	39.88
1995	59 756	39.89
2000	64 269	38.44
2005	68 435	37.70
2010	73 142	37.39
2011	74 224	37.80
2012	75 176	38.61
2013	76 148	38.47
2014	77 182	38.51
2015	78 218	39.43
2016	79 278	38.83
2017	80 313	39.64
2018	81 407	40.06
2019	82 579	39.78
2020	83 385	42.18
2021	84 147	42.22
2022	84 980	42.26

Source: (1) TurkStat, Mid-year Population Estimations and Projections
(2) FAOSTAT, Food Balance Sheets

Additional relevant parameters to calculate total nitrogen in the effluent are given in Table 7.44. Default values from the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.11* are used for the fraction of nitrogen in protein (0.16 kg N/kg protein), the fraction of non-consumed protein (1.4), and the fraction of industrial and commercial co-discharged protein (1.25). As discussed above for domestic wastewater, Türkiye assumes that there is zero sludge removed. Regarding the fraction of non-consumed protein, Türkiye has applied the value for developed countries using garbage disposals.

Table 7.44 Parameters for estimation of nitrogen in effluent

Fraction of nitrogen in protein (F_{NPR}) (kg N/kg protein)	Fraction of non-consumed protein ($F_{NON-CON}$)	Fraction of industrial and commercial co-discharged protein ($F_{IND-COM}$)	Nitrogen removed with sludge (N_{SLUDGE}) (kg)
0.16	1.40	1.25	0.00

Choice of Emission Factor

To estimate N_2O emissions from wastewater effluent, the IPCC default N_2O EF ($EF_{EFFLUENT}$) is selected as 0.005 kg N_2O-N/kg-N from the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.11*.

The IPCC default EF (EF_{PLANTS}) to estimate N_2O emissions from centralized wastewater treatment plants of 3.2 g N_2O/person/year as given in the 2006 IPCC Guidelines, *Volume 5, Chapter 6, Table 6.11* is applied. To estimate N_2O emissions from such plants, the country-specific values of the degree of utilization of modern, centralized WWT plants (T_{PLANT}) are calculated for the whole time series.

Uncertainties and Time-Series Consistency:

Domestic Wastewater Treatment and Discharge: For CH_4 emissions, the uncertainty for AD is estimated as 5.0% and for CH_4 EF it is calculated as 37.7% by using default uncertainty ranges provided in the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.7.*

For N_2O emissions, the uncertainty for AD is estimated as 30.0%. The uncertainty value of the N_2O EF is calculated as 42.4% by using uncertainty values of 30.0% for both $EF_{EFFLUENT}$ and EF_{PLANTS} based on expert judgment since there is no sufficient information in the related section of the 2006 IPCC.

Industrial Wastewater Treatment and Discharge: For CH_4 emissions, the uncertainty for AD is estimated as 11.2% and for CH_4 EF it is calculated as 39.1% by using default uncertainty ranges provided in the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.10.*

The estimates are calculated in a consistent manner over time series.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

The data used in Wastewater Treatment and Discharge (CRT Category 5.D) are derived from waste statistics database of TurkStat. TurkStat is producing all its statistics according to the European Code of Practice Principles. Therefore, high quality data are used in the emission estimates of this category.

Recalculation:

No recalculations were made for CH_4 emissions from domestic wastewater, but they were made for CH_4 emissions from industrial wastewater. In view of the availability of 2022 data, the 2021 data has been recalculated using the interpolation method. As a result of the this recalculation, methane emissions from industrial wastewater have changed 4.4% in 2021

In order to obtain the most up-to-date data on N_2O emissions, the 2010-2021 data from FAOSTAT was updated with the revised protein supply data, which replaced the previous FAOSTAT data. This resulted in the recalculation of the per capita protein consumption data. Additionally, a minor recalculation was conducted on the 2021 T_{PLANT} % from the previous submission. This was achieved through the utilization of the interpolation method, given the availability of the 2022 survey data. As a result nitrous oxide emissions have changed in figures ranging from 2.5% to -2.1% over the years 2010-2021.

Planned Improvement:

Türkiye is planning to improve the parameters used in the estimation of CH_4 emissions, both for the degree of treatment utilization by population class (domestic wastewater) and for the fraction usage for different types of wastewater treatment and discharge pathways (industrial wastewater) for the entire time series.

7.6. Other (Category 5.E)

There are no other activities to be considered under this category.

8. OTHER

Türkiye does not report any emissions under the category 'Other'.

9. INDIRECT CARBON DIOXIDE AND NITROUS OXIDE EMISSIONS

Türkiye does not report on indirect carbon dioxide and nitrous oxide emissions.

10. RECALCULATIONS AND IMPROVEMENTS

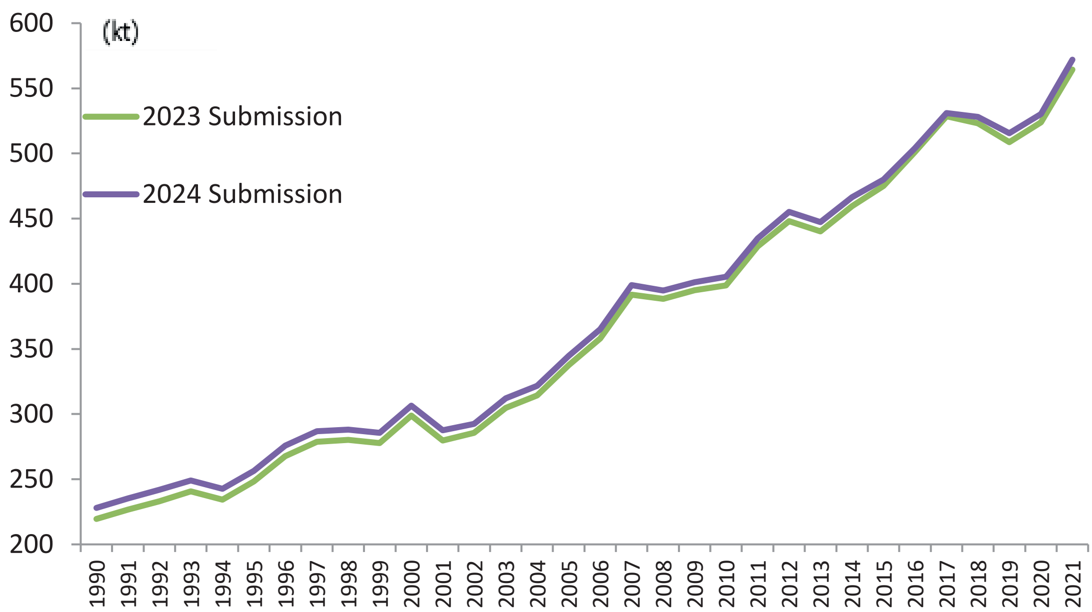
Recalculations:

Annually, the inventory team conducts a comprehensive analysis of the time series data from 1990 onwards to identify any conditions that do not comply with TACCC criteria. This examination informs the implementation of necessary adjustments, including Activity Data (AD) revisions, updates, emissions reallocations, and various refinements. Detailed descriptions of these recalculations, along with their underlying rationales, are presented in Chapters 3-7.

In alignment with the Modalities, Procedures, and Guidelines (MPGs), the inventory values submitted for 2024 are based on the Global Warming Potential (GWP) values specified in the IPCC Fifth Assessment Report (AR5). In contrast, the previous submission utilized GWP values from the Fourth Assessment Report (AR4). This transition necessitated recalculations to accurately reflect the updated GWP values. Consequently, while the 2023 inventory relied on AR4 GWP values, the 2024 inventory has been recalibrated to incorporate the revisions established in AR5.

Figure 10.1 illustrates the overall impact resulting from the recalculations.

Figure 10.1 overall impact resulting from the recalculations, 1990-2021



In energy sector;

In petroleum refining; In this submission, CO2 emissions from plants were taken from plants. Regulation on "Greenhouse Gases Emission Monitoring" went into force on April 25, 2012 with the publication of 28274 numbered official gazette. And plants started to report their 2018 emissions in 2020. 2018-2022 CO_2 emissions were taken directly from plants and 1990-2017 emissions were recalculated based on the amount of petroleum refined.

Emissions from manufacture and solid fuels for the years 1990-1993 and 2005-2020 were recalculated due to the calculation error. The effect of error varies between -6.25% and 3.7%.

There is recalculation due the minor changes of EF parameters and resulted as 1.4% change in iron and steel production for 2018 emissions.

Emissions from nonferrous metal were recalculated for the whole time series due to the revision of the country specific emission factor for solid fuels. Recalculation effected emission less than 0.1%.

There is recalculation in food processing, beverages and tobacco sector due to the revision of waste used as fuel between 0.02% and 0.3%
Emissions from non-metallic minerals were recalculated for the years 2019-2021 emission and resulted as 5-7% change for these years.

Emissions from other industries were recalculated for the year 2019-2021 due to the revision of AD. Recalculation effected emission between 7% and 4.7%.

Emissions from commercial/institutional and residential sectors were recalculated due to sub sectoral allocation for the years 1990-2014.

There is recalculation in fugitive emissions from solid fuels sector due to the amount of coal as recommended by ERT.

In IPPU sector;

The cement production activity data of a new plant, which became operational in 2021, has been included in the calculations.

The inclusion of data from two plants in glass production sector led to a recalculation between the years 1990-2021 in sectors 2.A.3 and 2.A.4.b.

Changes in production data in the PRODCOM database have been reflected in the calculations for sector 2.A.4.a.

The retrospective inclusion of styrene production resulted in a minor increase in CH_4 emissions from the petrochemical sector between 2007 and 2012.

For 2.C.1, the carbon content of pig iron and natural gas from a single integrated plant was adjusted for the years 2018 and 2019.

The amount of lead production from waste batteries in 2021 has been recalculated using linear interpolation, based on the availability of 2022 survey data.

The emissions of SF_6 from the electronic industry between the years 2010-2022 have been included and subsequently corrected.

For 2.G., the consumption of SF_6 in magnesium production between 2016-2021 has been accounted for, and calculation errors covering these years have been identified and corrected.

In agriculture sector;

For methane emissions from enteric fermentation, revisions are a result of an update in the EF used for merino sheep and of updates in feed digestibility coefficients for cattle.

For methane emissions from manure management, revisions are a result of a major improvement in the selection of emission factors for non-dairy cattle methane emissions. The division of culture-hybrid-domestic cattle used in the selection of emission factors for dairy cattle is also applied to non-dairy cattle in this submission.

For nitrous oxide emissions from agricultural soils, minor revisions are mainly a result of the newly added emissions related to the source category on soil organic matter and updated parameters affecting calculations of crop residues emissions.

For emissions from field burning of agricultural residues, minor revisions are a result of an updated fraction in the calculations.

In LULUCF sector;

The Forest Land Category was recalculated due to the change of the carbon fraction value of the mixed and degraded forest.

The weighted average of the perennial crop' carbon stock values found in Figure 6.21 of the MediNet Biomass Report of the Medinet project (Canaveira et al., 2018) according to the land statistics of the perennial plant crop types in the country (TURKSTAT Statistics) was calculated and used as 13.16 tons of C per hectar. Based on the 20-year rotation period, an annual increase was taken as 0.66 tons. The calculations are also reflected in all categories related to CL perennial.

In waste sector;

For category 5.A,

- Türkiye estimated the historical waste generation for 1950-1993 using gross domestic product as driver, and revised the waste per capita for those years.
- Türkiye assumed an oxidation factor of 0.1 for managed waste disposal sites.
- 2021 data of MSW disposed in managed SWDS has been recalculated by linear interpolation due to availability of 2022 survey data. The amount of MSW disposed in unmanaged SWDS for 2021 was also affected by this recalculation.
- 2021 waste composition data is recalculated due to the availability of 2022 survey which includes both 2021 and 2022 data.
- The revision of 2018-2021 GDP data by TurkStat resulted in changes in total industrial waste in the SWDS, which led to minor recalculation in CH4 emissions from unmanaged SWDS for the same period.
- 2021 waste generation rate of previous submission is recalculated by interpolation method due to availability of 2022 IW data. 2021 % to SWDS data of previous submission is also recalculated by interpolation method due to availability of 2022 IW generated data.

For category 5.B,

- Türkiye differentiated between the amounts of MSW composted and treated in an MBT facility, and for the MSW treated in an MBT facility, quantified the fraction of waste that is composted and use only this fraction as AD to estimate emissions from composting between 1990-2021.

For category 5.C (Incineration and Open Burning of Waste);

- 2021 data for the fraction of MSW open-burned has been recalculated by linear interpolation due to availability of 2022 survey data.
- 2021 waste composition data was revised with the acquisition of survey data.
- The amount of waste generated for the years 1990-1993 has been revised and this has affected the amount of open burning waste for the same years.

For category 5.D (Incineration and Open Burning of Waste);

- In view of the availability of 2022 data, the 2021 industrial wastewater data has been recalculated using the interpolation method. the 2010-2021 data from FAOSTAT was updated with the revised protein supply data, which replaced the previous FAOSTAT data. This resulted in the recalculation of the per capita protein consumption data and nitrous oxide emissions over the years 2010-2021.

Planned Improvements:

Considerable improvements have been made in this submission. However, there are still areas to be improved mainly related to using higher tiers, especially for key categories. Planned improvements are summarized as follows:

In energy sector;

MENR worked on agricultural association for modeling the agricultural diesel oil consumption and the disaggregation of diesel oil consumption was achieved in 2015 national energy balance tables. However national energy balance tables are not in time series therefore the allocation problem still exists between 2012 and 2014. All relevant institutions are working together and make planning in order to overcome this inconsistency problem.

Since the 1.B.1 category is a key category in terms of emission trend of CH_4, the tiers in CH_4 estimation needs to be increased. Detailed investigation has been performed to find out the availability of country specific or basin specific EFs within both general directorates for lignite and hard coal structured under the MENR, namely, DG Turkish Lignite Enterprises and DG Turkish Hard Coal Enterprises. However, information for the generation of country-specific EFs are not available centrally in those coal authorities. Therefore, it is necessary to communicate and cooperate with mining enterprises directly to search the availability of required information for T2 estimation of CH_4.

For 1.B.2 In order to increase the tiers for CH_4 emission estimation, availability of detailed information have been searched. It is planned to continue the investigation to find out the availability or possibility of availability of appropriate data for higher tiers.

In IPPU sector;

In the next years, emissions calculations for IPPU sub-sectors will utilize Monitoring, Reporting, and Verification (MRV) data provided by the Ministry of Environment, Urbanization, and Climate Change (MoEUCC). Over 800 plants are required to submit their verified annual emissions data from energy and industrial sectors in accordance with MoEUCC regulations. MRV data will be analyzed for various quality aspects, including coverage, accuracy, completeness, and consistency.

To ensure comprehensive and standardized MRV data, consultations with MoEUCC are ongoing to gather activity data and refine classifications. Once the data is standardized and complete, an accounting system will be established to calculate emissions using both current methodologies and MRV data. The results will be tracked and compared over two years before included in the Inventory.

In agriculture sector;

Türkiye considers the possibility of using Tier 2 method for estimating enteric fermentation emissions from sheep in the future and also searches for country specific parameters related to using Tier 2 method in manure management.

In LULUCF sector;

The planned improvements for Forest Land category are;

- Re-evaluation of the emission/other factors used for living biomass, DOM, and mineral soils based on Mediterranean Emission/Other factors Database by the collaboration program of ONF-GDF.
- Estimation of carbon stocks for carbon pools for which emissions are currently not reported, namely deadwood, litter and mineral soil.
- Preparation of input forest data and parameters for some of the existing forest models (e.g. CBM) to be able for running simulations and making projections of forest development under different scenarios.
- Development and establishment of National Forest Inventory (NFI) based on permanent sample plot system.
- Use a higher Tier level in reporting.
- Develop and use allometric equations instead of currently used national BCEF coefficients.
- Preparement of the land use matrix for 2020 or beyond.

The planned improvements for Cropland category are;

- Increase from Tier 1 to Tier 2 method in estimating the carbon stock change in living biomass in Land converted to cropland.
- Collection, sampling and/or modelling of carbon stocks in mineral soil at a larger spatial scale. (e.g. consider potential use of National Geospatial Soil Fertility and Soil Organic Carbon Information System)
- Data collection about management systems (land use, tillage, input) for Cropland remaining cropland, also through use of existing generalised maps of dominant crops in Türkiye.

The planned improvements for Grassland category are;

- Re-evaluation of the estimation of emissions due to drainage of organic soil.

- Check for the size of emission factors for the subcategory Land converted to grassland.
- Verification of assumptions by surveying national research studies and papers.
- Data collection about management systems (land use, management, input) for Grassland remaining grassland.
- Estimation of carbon stock changes in mineral soil for Grassland remaining grassland, using a default method. (applying SOCREF and stock change factors)
- Modelling of carbon stocks in mineral soil at a larger spatial scale. (e.g. considering potential use of National Geospatial Soil Fertility and Soil Organic Carbon Information System)

The planned improvements for Wetland category are;

- Use of Wetlands Supplement more effectively.
- Review all existing national and international databases related to wetlands. (e.g. Ramsar Convention on Wetlands, FAOSTAT, Wetlands International, NGO data etc.)
- Expert judgment (e.g. by national soil scientist) about different types of managed wetlands that are likely to occur in Türkiye.
- Collection of activity data regarding specific types of managed wetlands.
- Sampling of SOC and estimation of carbon stocks for major soil types of wetlands.

The planned improvements for Settlement category are;

- Update carbon stock changes for all relevant carbon pools for each land use conversion to settlements.
- Extend the study mentioned in the methodology section to other settlement areas and thus update the CS values.

In waste sector;

In the scope of TurkStat's *Waste Disposal and Recovery Facilities Survey*, it will be determined whether there is any flaring on waste disposal sites (CRT Category 5.A). Based on the gathered information, flaring would be included in next submission.

Emissions and amount of methane for energy recovery from anaerobic digestion at biogas facilities (CRT Category 5.B.2) will be included in next inventory submissions depending on the availability of such treatment processes.

In Wastewater Treatment and Discharge (CRT Category 5.D), Türkiye is planning to improve the parameters used in the estimation of CH_4 emissions, both for the degree of treatment utilization by population class (domestic wastewater) and for the fraction usage for different types of wastewater treatment and discharge pathways (industrial wastewater) for the entire time series.

Annex 1: Key Categories

This annex presents the results of Approach 1 and Approach 2 key category analysis and results for the latest Turkish GHG inventory submission. The 2006 IPCC Guidelines for National GHG Inventories (2006 IPCC Guidelines) recommend as good practice the identification of key categories of emissions and removals. The objective is to assist inventory agencies in their prioritization efforts to improve overall estimates. A key category is defined as "one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions and removals" (2006 IPCC Guidelines); this term is used in reference to both source and sink categories.

The Approach 1 Level and Trend Assessment described in the 2006 IPCC Guidelines Vol.1, Chapter 4 is used to identify key categories from two perspectives: their contribution to the overall emissions and their contribution to the emission trend. The level assessment analyses the emission contribution that each category makes to the national total (with and without LULUCF). The trend assessment uses each category's relative contribution to the overall emissions, but assigns greater weight to the categories whose relative trend departs from the overall trend (with and without LULUCF). In this assessment, trends are calculated as the absolute changes between base year and most recent inventory year.

The percent contributions to both levels and trends in emissions are calculated and sorted in descending order. A cumulative total is calculated for both approaches. A cumulative contribution threshold of 95% for both level and trend assessments is a reasonable approximation of 90% uncertainty for the T1 method of determining key categories (2006 IPCC Guidelines). This threshold has therefore been used in this analysis to define an upper boundary for key category identification. Therefore, when source and sink contributions are sorted in decreasing order of importance, those largest ones that together contribute to 95% of the cumulative total are considered quantitatively to be key categories.

For this inventory submission, level and trend key category assessments are performed not only according to the recommended IPCC approach given in Volume 1, Section 4.3.1 (Approach 1), but also given in Section 4.3.2 (Approach 2) of the 2006 IPCC Guidelines. Based on the Approach 1 key category analysis (with/without LULUCF) and on the Approach 2 key category analysis (without LULUCF), Table A.1, on the next page, presents 34 key categories in 2022.

Table A1 Key category analysis summary, 2022

KEY CATEGORIES OF EMISSIONS AND REMOVALS	Gas	Criteria used for key category identification		Key category excluding LULUCF	Key category including LULUCF
		L	T		
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	X	X	X	X
1.A.3.a Domestic Aviation	CO2	X		X	X
1.A.3.b Road Transportation	CO2	X	X	X	X
1.A.3.b Road Transportation	N2O	X		X	
1.A.4 Other Sectors - Liquid Fuels	CO2	X	X	X	X
1.A.4 Other Sectors - Liquid Fuels	N2O	X	X	X	
1.A.4 Other Sectors - Solid Fuels	CO2	X	X	X	X
1.A.4 Other Sectors - Solid Fuels	N2O		X	X	
1.A.4 Other Sectors - Gaseous Fuels	CO2	X	X	X	X
1.A.4 Other Sectors - Biomass	CH4	X	X	X	X
1.A.4 Other Sectors - Biomass	N2O		X	X	
1.B.1 Fugitive emissions from Solid Fuels	CH4	X	X	X	X
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH4	X	X	X	X
2.A.1 Cement Production	CO2	X	X	X	X
2.A.2 Lime Production	CO2		X	X	X
2.A.4 Other Process Uses of Carbonates	CO2	X		X	X
2.C.1 Iron and Steel Production	CO2	X	X	X	X
2.F.6 Other Applications	HFCs	X	X	X	X
3.A Enteric Fermentation	CH4	X	X	X	X
3.B Manure Management	CH4	X	X	X	X
3.B Manure Management	N2O	X	X	X	X
3.D.1 Direct N2O Emissions From Managed Soils	N2O	X	X	X	X
3.D.2 Indirect N2O Emissions From Managed Soils	N2O	X	X	X	X
4.A.1 Forest Land Remaining Forest Land	CO2	X	X		X
4.G Harvested Wood Products	CO2	X	X		X
5.A Solid Waste Disposal	CH4	X	X	X	X
5.D Wastewater Treatment and Discharge	CH4	X	X	X	X
5.D Wastewater Treatment and Discharge	N2O	X		X	

Table A2 Approach 1 Key category analysis level assessment with LULUCF, 2022

	Category	Fuel	GAS	2022 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.1.	Energy industries	Solid fuels	CO2	115 999	115 999	18.73	18.73
1.A.3.b.	Road Transportation		CO2	84 698	84 698	13.67	32.40
1.A.4.	Other sectors	Gaseous fuels	CO2	46 169	46 169	7.45	39.85
4.A.1.	Forest Land Remaining Forest Land		CO2	-44 587	44 587	7.20	47.05
2.A.1.	Cement Production (Mineral Products)		CO2	40 007	40 007	6.46	53.51
3.A.	Enteric fermentation		CH4	38 244	38 244	6.17	59.68
1.A.1.	Energy industries	Gaseous fuels	CO2	30 117	30 117	4.86	64.54
1.A.2.	Manufacturing industries and construction	Solid fuels	CO2	25 581	25 581	4.13	68.67
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CO2	21 100	21 100	3.41	72.08
3.D.1	Direct N2O emissions from managed soils		N2O	19 790	19 790	3.19	75.27
1.A.4.	Other sectors	Solid fuels	CO2	14 400	14 400	2.32	77.60
1.A.2.	Manufacturing industries and construction	Liquid fuels	CO2	13 840	13 840	2.23	79.83
4.G.	Harvested Wood Products		CO2	-13 689	13 689	2.21	82.04
1.A.4.	Other sectors	Liquid fuels	CO2	11 676	11 676	1.88	83.92
5.A.	Solid waste disposal		CH4	10 613	10 613	1.71	85.64
2.F.6.	Other applications		HFC	9 782	9 782	1.58	87.22
2.C.1.	Iron and Steel Production		CO2	9 629	9 629	1.55	88.77
1.A.1.	Energy industries	Liquid fuels	CO2	8 568	8 568	1.38	90.15
1.B.1	Fugitive emissions from solid fuels		CH4	8 332	8 332	1.34	91.50
3.B.	Manure management		CH4	4 983	4 983	0.80	92.30
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CO2	4 570	4 570	0.74	93.04
3.B.	Manure management		N2O	4 366	4 366	0.70	93.75
5.D.	Wastewater treatment and discharge		CH4	3 488	3 488	0.56	94.31
1.A.3.a.	Domestic Aviation		CO2	3 335	3 335	0.54	94.85
2.A.4.	Other process uses of carbonates		CO2	2 855	2 855	0.46	95.31
1.B.2.b	Fugitive emissions from fuels	Natural Gas	CH4	2 532	2 532	0.41	95.72
3.D.2	Indirect N2O Emissions from managed soils		N2O	2 527	2 527	0.41	96.12
2.A.2.	Lime Production (Mineral Products)		CO2	2 272	2 272	0.37	96.49
5.D.	Wastewater treatment and discharge		N2O	2 132	2 132	0.34	96.84
2.B.2.	Nitric acid production		N2O	1 580	1 580	0.26	97.09
1.A.3.b.	Road Transportation		N2O	1 251	1 251	0.20	97.29
3.H.	Urea application		CO2	1 138	1 138	0.18	97.48
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO2	1 073	1 073	0.17	97.65
1.A.4.	Other sectors	Solid fuels	CH4	1 018	1 018	0.16	97.81

Table A2 Approach 1 Key category analysis level assessment with LULUCF, 2022 (cont'd)

	Category	Fuel	GAS	2022 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.4.	Other sectors	Liquid fuels	N2O	1 011	1 011	0.16	97.98
2.A.3.	Glass Production		CO2	875.9	875.9	0.14	98.12
4.F.2.	Land Converted to Other Land		CO2	734.7	734.7	0.12	98.24
2.B.1.	Ammonia Production		CO2	701.4	701.4	0.11	98.35
1.A.1.	Energy industries	Solid fuels	N2O	697.2	697.2	0.11	98.46
2.B.7.	Soda ash production		CO2	653.5	653.5	0.11	98.57
4.C.2.	Land Converted to Grassland		CO2	625.5	625.5	0.10	98.67
1.B.2.c	Venting and flaring		CH4	616.7	616.7	0.10	98.77
1.A.4.	Other sectors	Biomass	CH4	577.7	577.7	0.09	98.86
4.B.2.	Land Converted to Cropland		CO2	548.9	548.9	0.09	98.95
4.E.2.	Land Converted to Settlements		CO2	509.2	509.2	0.08	99.03
2.C.6.	Zinc Production		CO2	508.5	508.5	0.08	99.12
1.B.2.a	Oil		CH4	478.4	478.4	0.08	99.19
1.A.3.b.	Road Transportation		CH4	459.4	459.4	0.07	99.27
1.A.3.c.	Railways		CO2	456.7	456.7	0.07	99.34
1.A.3.e.	Other transportation		CO2	438.3	438.3	0.07	99.41
2.F.3.	Fire protection		HFC	401.8	401.8	0.06	99.48
1.A.1.	Energy industries	Gaseous fuels	N2O	358.4	358.4	0.06	99.53
3.C.	Rice cultivation		CH4	279.9	279.9	0.05	99.58
4.A.2.	Land Converted to Forest Land		CO2	-278.6	278.6	0.04	99.62
1.B.2.c	Venting and flaring		CO2	210.5	210.5	0.03	99.66
3.F.	Field burning of agricultural residues		CH4	146.5	146.5	0.02	99.68
2.D.1.	Lubricant Use		CO2	139.0	139.0	0.02	99.70
2.C.2.	Ferroalloys Production		CO2	124.9	124.9	0.02	99.72
2.C.3.	Aluminium Production		CO2	117.7	117.7	0.02	99.74
1.A.4.	Other sectors	Gaseous fuels	CH4	116.0	116.0	0.02	99.76
4.D.2.	Land Converted to Wetlands		CO2	-101.6	101.6	0.02	99.78
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	96.9	96.9	0.02	99.79
2.G.1.	Electrical equipment		SF6	93.6	93.6	0.02	99.81
1.A.4.	Other sectors	Biomass	N2O	72.9	72.9	0.01	99.82
4.A.1.	Forest Land Remaining Forest Land		CH4	72.2	72.2	0.01	99.83
2.E.5.	Other		SF6	70.8	70.8	0.01	99.84
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	68.4	68.4	0.01	99.85
1.A.1.	Energy industries	Biomass	N2O	67.3	67.3	0.01	99.87

Table A2 Approach 1 Key category analysis level assessment with LULUCF, 2022 (cont'd)

	Category	Fuel	GAS	2022 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.1.	Energy industries	Other fossil fuels	CO2	65.2	65.2	0.01	99.88
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	62.7	62.7	0.01	99.89
1.A.4.	Other sectors	Solid fuels	N2O	58.3	58.3	0.01	99.90
1.A.2.	Manufacturing industries and construction	Biomass	N2O	50.1	50.1	0.01	99.90
1.A.3.c.	Railways		N2O	47.9	47.9	0.01	99.91
2.C.4.	Magnesium Production		SF6	44.0	44.0	0.01	99.92
1.A.2.	Manufacturing industries and construction	Biomass	CH4	39.7	39.7	0.01	99.93
4.A.1.	Forest Land Remaining Forest Land		N2O	37.8	37.8	0.01	99.93
3.F.	Field burning of agricultural residues		N2O	36.0	36.0	0.01	99.94
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	33.9	33.9	0.01	99.94
1.A.3.a.	Domestic Aviation		N2O	30.5	30.5	0.00	99.95
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	26.8	26.8	0.00	99.95
4.B.2.	Land Converted to Cropland		N2O	24.6	24.6	0.00	99.96
1.A.1.	Energy industries	Solid fuels	CH4	23.0	23.0	0.00	99.96
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	22.5	22.5	0.00	99.96
1.A.4.	Other sectors	Gaseous fuels	N2O	22.0	22.0	0.00	99.97
1.A.1.	Energy industries	Gaseous fuels	CH4	21.2	21.2	0.00	99.97
1.A.4.	Other sectors	Liquid fuels	CH4	20.3	20.3	0.00	99.97
2.C.1.	Iron and Steel Production		CH4	16.5	16.5	0.00	99.98
5.B.	Biological treatment of solid waste		CH4	13.0	13.0	0.00	99.98
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	12.0	12.0	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	10.6	10.6	0.00	99.98
1.A.1.	Energy industries	Biomass	CH4	10.2	10.2	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	10.0	10.0	0.00	99.98
2.C.5.	Lead Production		CO2	9.1	9.1	0.00	99.99
2.D.2.	Paraffin Wax Use		CO2	8.9	8.9	0.00	99.99
2.B.5.	Carbide production		CO2	7.9	7.9	0.00	99.99
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N2O	7.9	7.9	0.00	99.99
2.C.3.	Aluminium Production		PFC	7.7	7.7	0.00	99.99
5.B.	Biological treatment of solid waste		N2O	7.4	7.4	0.00	99.99
5.C.	Incineration and open burning of waste		CH4	5.7	5.7	0.00	99.99
1.A.1.	Energy industries	Liquid fuels	N2O	5.6	5.6	0.00	99.99
5.C.	Incineration and open burning of waste		CO2	5.3	5.3	0.00	100.00
1.B.2.a	Oil		CO2	4.0	4.0	0.00	100.00

Table A2 Approach 1 Key category analysis level assessment with LULUCF, 2022 (cont'd)

	Category	Fuel	GAS	2022 Emission	ABS (Emission)	Cont. (%)	Cumulative
4.D.2.	Land Converted to Wetlands		N2O	3.9	3.9	0.00	100.00
1.B.2.b	Natural Gas		CO2	3.1	3.1	0.00	100.00
1.A.1.	Energy industries	Liquid fuels	CH4	3.0	3.0	0.00	100.00
4.C.2.	Land Converted to Grassland		N2O	2.9	2.9	0.00	100.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH4	2.9	2.9	0.00	100.00
1.A.3.a.	Domestic Aviation		CH4	1.5	1.5	0.00	100.00
2.B.8.	Petrochemical and carbon black production		CO2	1.2	1.2	0.00	100.00
1.B.2.c	Venting and flaring		N2O	0.8	0.8	0.00	100.00
5.C.	Incineration and open burning of waste		N2O	0.8	0.8	0.00	100.00
1.A.3.c.	Railways		CH4	0.7	0.7	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	N2O	0.7	0.7	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	CH4	0.6	0.6	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	0.4	0.4	0.00	100.00
4.A.2.	Land Converted to Forest Land		CH4	0.3	0.3	0.00	100.00
1.A.3.e.	Other transportation		CH4	0.2	0.2	0.00	100.00
1.A.3.e.	Other transportation		N2O	0.2	0.2	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH4	0.2	0.2	0.00	100.00
4.A.2.	Land Converted to Forest Land		N2O	0.2	0.2	0.00	100.00
1.C.	CO2 Transport and storage		CO2	0.1	0.1	0.00	100.00
2.E.5.	Other		HFC	0.1	0.1	0.00	100.00
2.E.5.	Other		PFC	0.0	0.0	0.00	100.00
Total				**502 174.97**	**619 486.66**		

Table A3 Approach 1 Key category analysis level assessment without LULUCF, 2022

	Category	Fuel	GAS	2022 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.1.	Energy industries	Solid fuels	CO2	115 999	115 999	20.78	20.78
1.A.3.b.	Road Transportation		CO2	84 698	84 698	15.17	35.95
1.A.4.	Other sectors	Gaseous fuels	CO2	46 169	46 169	8.27	44.22
2.A.1.	Cement Production (Mineral Products)		CO2	40 007	40 007	7.17	51.39
3.A.	Enteric fermentation		CH4	38 244	38 244	6.85	58.24
1.A.1.	Energy industries	Gaseous fuels	CO2	30 117	30 117	5.39	63.63
1.A.2.	Manufacturing industries and construction	Solid fuels	CO2	25 581	25 581	4.58	68.21
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CO2	21 100	21 100	3.78	71.99
3.D.1	Direct N2O emissions from managed soils		N2O	19 790	19 790	3.54	75.54
1.A.4.	Other sectors	Solid fuels	CO2	14 400	14 400	2.58	78.12
1.A.2.	Manufacturing industries and construction	Liquid fuels	CO2	13 840	13 840	2.48	80.60
1.A.4.	Other sectors	Liquid fuels	CO2	11 676	11 676	2.09	82.69
5.A.	Solid waste disposal		CH4	10 613	10 613	1.90	84.59
2.F.6.	Other applications		HFC	9 782	9 782	1.75	86.34
2.C.1.	Iron and Steel Production		CO2	9 629	9 629	1.72	88.07
1.A.1.	Energy industries	Liquid fuels	CO2	8 568	8 568	1.53	89.60
1.B.1	Fugitive emissions from solid fuels		CH4	8 332	8 332	1.49	91.09
3.B.	Manure management		CH4	4 983	4 983	0.89	91.99
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CO2	4 570	4 570	0.82	92.80
3.B.	Manure management		N2O	4 366	4 366	0.78	93.59
5.D.	Wastewater treatment and discharge		CH4	3 488	3 488	0.62	94.21
1.A.3.a.	Domestic Aviation		CO2	3 335	3 335	0.60	94.81
2.A.4.	Other process uses of carbonates		CO2	2 855	2 855	0.51	95.32
1.B.2.b	Fugitive emissions from fuels	Natural Gas	CH4	2 532	2 532	0.45	95.77
3.D.2	Indirect N2O Emissions from managed soils		N2O	2 527	2 527	0.45	96.23
2.A.2.	Lime Production (Mineral Products)		CO2	2 272	2 272	0.41	96.63
5.D.	Wastewater treatment and discharge		N2O	2 132	2 132	0.38	97.02
2.B.2.	Nitric acid production		N2O	1 580	1 580	0.28	97.30
1.A.3.b.	Road Transportation		N2O	1 251	1 251	0.22	97.52
3.H.	Urea application		CO2	1 138	1 138	0.20	97.73
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO2	1 073	1 073	0.19	97.92
1.A.4.	Other sectors	Solid fuels	CH4	1 018	1 018	0.18	98.10
1.A.4.	Other sectors	Liquid fuels	N2O	1 011	1 011	0.18	98.28
2.A.3.	Glass Production		CO2	875.9	875.9	0.16	98.44

Table A3 Approach 1 Key category analysis level assessment without LULUCF, 2022 (cont'd)

	Category	Fuel	GAS	2022 Emission	ABS (Emission)	Cont. (%)	Cumulative
2.B.1.	Ammonia Production		CO2	701.4	701.4	0.13	98.56
1.A.1.	Energy industries	Solid fuels	N2O	697.2	697.2	0.12	98.69
2.B.7.	Soda ash production		CO2	653.5	653.5	0.12	98.81
1.B.2.c	Venting and flaring		CH4	616.7	616.7	0.11	98.92
1.A.4.	Other sectors	Biomass	CH4	577.7	577.7	0.10	99.02
2.C.6.	Zinc Production		CO2	508.5	508.5	0.09	99.11
1.B.2.a	Oil		CH4	478.4	478.4	0.09	99.20
1.A.3.b.	Road Transportation		CH4	459.4	459.4	0.08	99.28
1.A.3.c.	Railways		CO2	456.7	456.7	0.08	99.36
1.A.3.e.	Other transportation		CO2	438.3	438.3	0.08	99.44
2.F.3.	Fire protection		HFC	401.8	401.8	0.07	99.51
1.A.1.	Energy industries	Gaseous fuels	N2O	358.4	358.4	0.06	99.58
3.C.	Rice cultivation		CH4	279.9	279.9	0.05	99.63
1.B.2.c	Venting and flaring		CO2	210.5	210.5	0.04	99.66
3.F.	Field burning of agricultural residues		CH4	146.5	146.5	0.03	99.69
2.D.1.	Lubricant Use		CO2	139.0	139.0	0.02	99.72
2.C.2.	Ferroalloys Production		CO2	124.9	124.9	0.02	99.74
2.C.3.	Aluminium Production		CO2	117.7	117.7	0.02	99.76
1.A.4.	Other sectors	Gaseous fuels	CH4	116.0	116.0	0.02	99.78
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	96.9	96.9	0.02	99.80
2.G.1.	Electrical equipment		SF6	93.6	93.6	0.02	99.81
1.A.4.	Other sectors	Biomass	N2O	72.9	72.9	0.01	99.83
2.E.5.	Other		SF6	70.8	70.8	0.01	99.84
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	68.4	68.4	0.01	99.85
1.A.1.	Energy industries	Biomass	N2O	67.3	67.3	0.01	99.86
1.A.1.	Energy industries	Other fossil fuels	CO2	65.2	65.2	0.01	99.88
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	62.7	62.7	0.01	99.89
1.A.4.	Other sectors	Solid fuels	N2O	58.3	58.3	0.01	99.90
1.A.2.	Manufacturing industries and construction	Biomass	N2O	50.1	50.1	0.01	99.91
1.A.3.c.	Railways		N2O	47.9	47.9	0.01	99.91
2.C.4.	Magnesium Production		SF6	44.0	44.0	0.01	99.92
1.A.2.	Manufacturing industries and construction	Biomass	CH4	39.7	39.7	0.01	99.93
3.F.	Field burning of agricultural residues		N2O	36.0	36.0	0.01	99.94
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	33.9	33.9	0.01	99.94

Table A3 Approach 1 Key category analysis level assessment without LULUCF, 2022 (cont'd)

	Category	Fuel	GAS	2022 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.3.a.	Domestic Aviation		N2O	30.5	30.5	0.01	99.95
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	26.8	26.8	0.00	99.95
1.A.1.	Energy industries	Solid fuels	CH4	23.0	23.0	0.00	99.96
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	22.5	22.5	0.00	99.96
1.A.4.	Other sectors	Gaseous fuels	N2O	22.0	22.0	0.00	99.96
1.A.1.	Energy industries	Gaseous fuels	CH4	21.2	21.2	0.00	99.97
1.A.4.	Other sectors	Liquid fuels	CH4	20.3	20.3	0.00	99.97
2.C.1.	Iron and Steel Production		CH4	16.5	16.5	0.00	99.97
5.B.	Biological treatment of solid waste		CH4	13.0	13.0	0.00	99.98
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	12.0	12.0	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	10.6	10.6	0.00	99.98
1.A.1.	Energy industries	Biomass	CH4	10.2	10.2	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	10.0	10.0	0.00	99.98
2.C.5.	Lead Production		CO2	9.1	9.1	0.00	99.99
2.D.2.	Paraffin Wax Use		CO2	8.9	8.9	0.00	99.99
2.B.5.	Carbide production		CO2	7.9	7.9	0.00	99.99
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N2O	7.9	7.9	0.00	99.99
2.C.3.	Aluminium Production		PFC	7.7	7.7	0.00	99.99
5.B.	Biological treatment of solid waste		N2O	7.4	7.4	0.00	99.99
5.C.	Incineration and open burning of waste		CH4	5.7	5.7	0.00	99.99
1.A.1.	Energy industries	Liquid fuels	N2O	5.6	5.6	0.00	100.00
5.C.	Incineration and open burning of waste		CO2	5.3	5.3	0.00	100.00
1.B.2.a	Oil		CO2	4.0	4.0	0.00	100.00
1.B.2.b	Natural Gas		CO2	3.1	3.1	0.00	100.00
1.A.1.	Energy industries	Liquid fuels	CH4	3.0	3.0	0.00	100.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH4	2.9	2.9	0.00	100.00
1.A.3.a.	Domestic Aviation		CH4	1.5	1.5	0.00	100.00
2.B.8.	Petrochemical and carbon black production		CO2	1.2	1.2	0.00	100.00
1.B.2.c	Venting and flaring		N2O	0.8	0.8	0.00	100.00
5.C.	Incineration and open burning of waste		N2O	0.8	0.8	0.00	100.00
1.A.3.c.	Railways		CH4	0.7	0.7	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	N2O	0.7	0.7	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	CH4	0.6	0.6	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	0.4	0.4	0.00	100.00

Table A3 Approach 1 Key category analysis level assessment without LULUCF, 2022 (cont'd)

	Category	Fuel	GAS	2022 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.3.e.	Other transportation		CH4	0.2	0.2	0.00	100.00
1.A.3.e.	Other transportation		N2O	0.2	0.2	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH4	0.2	0.2	0.00	100.00
1.C.	CO2 Transport and storage		CO2	0.1	0.1	0.00	100.00
2.E.5.	Other		HFC	0.1	0.1	0.00	100.00
2.E.5.	Other		PFC	0.0	0.0	0.00	100.00
Total				**558 270.48**	**558 270.48**		

Table A4 Approach 1 Key category analysis trend assessment with LULUCF, 2022

	Category	Fuel	Gas	2022	1990	Trend	Cont	Cum.
1.A.1.	Energy industries	Solid fuels	CO2	115 999.22	26 244.22	0.202	14.24	14.24
4.A.1.	Forest Land Remaining Forest Land		CO2	-44 587.00	-63 645.23	0.185	13.06	27.30
1.A.4.	Other sectors	Gaseous fuels	CO2	46 168.72	93.89	0.156	11.02	38.31
1.A.3.b.	Road Transportation		CO2	84 698.25	24 142.97	0.111	7.83	46.14
3.A.	Enteric fermentation		CH4	38 243.90	29 996.47	0.090	6.33	52.47
1.A.2.	Manufacturing industries and construction	Solid fuels	CO2	25 581.49	22 199.68	0.076	5.34	57.81
1.A.4.	Other sectors	Liquid fuels	CO2	11 676.10	14 433.04	0.066	4.66	62.46
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CO2	21 100.34	1 557.79	0.060	4.25	66.72
2.A.1.	Cement Production (Mineral Products)		CO2	40 006.67	10 444.54	0.059	4.19	70.91
1.A.4.	Other sectors	Solid fuels	CO2	14 400.03	14 749.94	0.059	4.17	75.08
1.A.1.	Energy industries	Gaseous fuels	CO2	30 117.34	6 279.95	0.056	3.97	79.05
1.A.2.	Manufacturing industries and construction	Liquid fuels	CO2	13 839.81	13 246.53	0.050	3.53	82.58
3.D.1	Direct N2O emissions from managed soils		N2O	19 790.26	13 490.36	0.032	2.23	84.80
1.A.1.	Energy industries	Liquid fuels	CO2	8 568.03	7 066.65	0.023	1.60	86.40
4.G.	Harvested Wood Products		CO2	-13 688.66	-2 947.74	0.022	1.56	87.96
2.C.1.	Iron and Steel Production		CO2	9 629.32	6 938.83	0.018	1.28	89.24
1.A.4.	Other sectors	Biomass	CH4	577.72	2 534.96	0.017	1.17	90.41
2.F.6.	Other applications		HFC	9 782.20		0.016	1.12	91.52
5.D.	Wastewater treatment and discharge		CH4	3 487.98	3 123.72	0.011	0.78	92.30
2.A.2.	Lime Production (Mineral Products)		CO2	2 272.29	2 248.73	0.009	0.62	92.92
1.B.2.b	Fugitive emissions from fuels	Natural Gas	CH4	2 532.46	160.94	0.007	0.52	93.44
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CO2	4 570.50		0.007	0.52	93.96
5.A.	Solid waste disposal		CH4	10 612.81	5 787.87	0.006	0.45	94.41
3.D.2	Indirect N2O Emissions from managed soils		N2O	2 527.49	1 900.74	0.005	0.38	94.79
3.B.	Manure management		N2O	4 366.41	2 742.73	0.005	0.37	95.16
2.A.4.	Other process uses of carbonates		CO2	2 854.89	618.64	0.005	0.36	95.52
1.A.4.	Other sectors	Solid fuels	CH4	1 018.29	1 146.02	0.005	0.35	95.87
1.A.3.a.	Domestic Aviation		CO2	3 334.88	913.74	0.005	0.33	96.20
1.B.1	Fugitive emissions from solid fuels		CH4	8 332.06	4 400.68	0.004	0.28	96.47
3.B.	Manure management		CH4	4 983.00	2 775.69	0.003	0.24	96.71
1.A.3.c.	Railways		CO2	456.71	651.19	0.003	0.23	96.94
2.C.3.	Aluminium Production		PFC	7.72	424.66	0.003	0.22	97.16
2.A.3.	Glass Production		CO2	875.89	111.68	0.002	0.15	97.31
5.D.	Wastewater treatment and discharge		N2O	2 131.91	1 281.42	0.002	0.15	97.46

Table A4 Approach 1 Key category analysis trend assessment with LULUCF, 2022 (cont'd)

	Category	Fuel	Gas	2022	1990	Trend	Cont	Cum.
1.A.4.	Other sectors	Biomass	N2O	72.90	319.89	0.002	0.15	97.61
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO2	1 072.82	220.75	0.002	0.14	97.75
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	62.73	282.87	0.002	0.13	97.88
1.B.2.a	Oil		CH4	478.44	470.26	0.002	0.13	98.01
1.A.1.	Energy industries	Solid fuels	N2O	697.17	86.21	0.002	0.12	98.13
3.F.	Field burning of agricultural residues		CH4	146.54	296.94	0.002	0.12	98.25
2.B.2.	Nitric acid production		N2O	1 580.39	945.85	0.002	0.11	98.36
2.C.6.	Zinc Production		CO2	508.46	37.84	0.001	0.10	98.46
1.A.3.e.	Other transportation		CO2	438.27	39.29	0.001	0.08	98.55
1.A.1.	Energy industries	Gaseous fuels	N2O	358.39	2.74	0.001	0.08	98.63
4.F.2.	Land Converted to Other Land		CO2	734.74		0.001	0.08	98.72
4.A.2.	Land Converted to Forest Land		CO2	-278.62	20.70	0.001	0.08	98.79
1.A.4.	Other sectors	Liquid fuels	N2O	1 011.18	615.52	0.001	0.08	98.87
2.B.7.	Soda ash production		CO2	653.48		0.001	0.07	98.94
1.B.2.c	Venting and flaring		CH4	616.72	142.23	0.001	0.07	99.02
4.C.2.	Land Converted to Grassland		CO2	625.52		0.001	0.07	99.09
4.B.2.	Land Converted to Cropland		CO2	548.91		0.001	0.06	99.15
1.B.2.c	Venting and flaring		CO2	210.54	217.58	0.001	0.06	99.21
4.E.2.	Land Converted to Settlements		CO2	509.19		0.001	0.06	99.27
2.D.1.	Lubricant Use		CO2	138.99	175.11	0.001	0.06	99.33
1.A.3.b.	Road Transportation		CH4	459.35	108.07	0.001	0.05	99.38
1.A.3.b.	Road Transportation		N2O	1 250.61	478.17	0.001	0.05	99.44
2.B.1.	Ammonia Production		CO2	701.41	424.76	0.001	0.05	99.49
2.F.3.	Fire protection		HFC	401.76		0.001	0.05	99.53
2.B.8.	Petrochemical and carbon black production		CO2	1.25	81.49	0.001	0.04	99.57
5.C.	Incineration and open burning of waste		CH4	5.65	74.12	0.001	0.04	99.61
3.H.	Urea application		CO2	1 138.12	459.95	0.000	0.04	99.65
4.A.1.	Forest Land Remaining Forest Land		CH4	72.21	92.45	0.000	0.03	99.68
3.F.	Field burning of agricultural residues		N2O	35.96	72.86	0.000	0.03	99.71
2.B.5.	Carbide production		CO2	7.92	58.99	0.000	0.03	99.73
1.A.4.	Other sectors	Gaseous fuels	CH4	116.01	0.24	0.000	0.03	99.76
2.C.3.	Aluminium Production		CO2	117.74	99.16	0.000	0.02	99.78
1.A.3.c.	Railways		N2O	47.89	61.10	0.000	0.02	99.80
4.A.1.	Forest Land Remaining Forest Land		N2O	37.81	47.52	0.000	0.02	99.82

Table A4 Approach 1 Key category analysis trend assessment with LULUCF, 2022 (cont'd)

	Category	Fuel	Gas	2022	1990	Trend	Cont	Cum.
1.A.4.	Other sectors	Solid fuels	N2O	58.33	54.25	0.000	0.01	99.83
1.A.4.	Other sectors	Liquid fuels	CH4	20.34	34.51	0.000	0.01	99.85
4.D.2.	Land Converted to Wetlands		CO2	-101.56		0.000	0.01	99.86
2.G.1.	Electrical equipment		SF6	93.58		0.000	0.01	99.87
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	96.88	64.56	0.000	0.01	99.88
3.C.	Rice cultivation		CH4	279.87	112.09	0.000	0.01	99.89
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	22.54	26.78	0.000	0.01	99.90
2.E.5.	Other		SF6	70.78		0.000	0.01	99.91
1.A.1.	Energy industries	Biomass	N2O	67.27	0.00	0.000	0.01	99.91
1.A.1.	Energy industries	Other fossil fuels	CO2	65.15		0.000	0.01	99.92
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	68.38	45.74	0.000	0.01	99.93
1.A.2.	Manufacturing industries and construction	Biomass	N2O	50.10	0.00	0.000	0.01	99.93
1.A.4.	Other sectors	Gaseous fuels	N2O	21.96	0.04	0.000	0.01	99.94
2.C.4.	Magnesium Production		SF6	43.99		0.000	0.01	99.94
5.C.	Incineration and open burning of waste		N2O	0.78	9.82	0.000	0.00	99.95
1.A.2.	Manufacturing industries and construction	Biomass	CH4	39.70		0.000	0.00	99.95
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	12.02	14.18	0.000	0.00	99.96
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	33.88	0.00	0.000	0.00	99.96
1.A.1.	Energy industries	Gaseous fuels	CH4	21.20	2.90	0.000	0.00	99.97
1.A.1.	Energy industries	Liquid fuels	N2O	5.57	8.84	0.000	0.00	99.97
1.A.3.a.	Domestic Aviation		N2O	30.51	7.90	0.000	0.00	99.97
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	26.85		0.000	0.00	99.97
4.B.2.	Land Converted to Cropland		N2O	24.64		0.000	0.00	99.98
1.A.1.	Energy industries	Solid fuels	CH4	23.03	6.51	0.000	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	10.60	0.79	0.000	0.00	99.98
2.D.2.	Paraffin Wax Use		CO2	8.93	8.25	0.000	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	10.04	0.74	0.000	0.00	99.99
2.C.2.	Ferroalloys Production		CO2	124.85	61.56	0.000	0.00	99.99
1.A.1.	Energy industries	Biomass	CH4	10.16		0.000	0.00	99.99
5.B.	Biological treatment of solid waste		CH4	13.00	8.16	0.000	0.00	99.99
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N2O	7.87	1.59	0.000	0.00	99.99
2.C.5.	Lead Production		CO2	9.08	2.20	0.000	0.00	99.99
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	0.43	1.91	0.000	0.00	99.99
4.A.2.	Land Converted to Forest Land		CH4	0.29	1.74	0.000	0.00	99.99

Table A4 Approach 1 Key category analysis trend assessment with LULUCF, 2022 (cont'd)

	Category	Fuel	Gas	2022	1990	Trend	Cont.	Cum.
4.A.2.	Land Converted to Forest Land		CH4	0.29	1.74	0.000	0.00	99.99
5.B.	Biological treatment of solid waste		N2O	7.38	4.63	0.000	0.00	99.99
5.C.	Incineration and open burning of waste		CO2	5.35	26.14	0.000	0.00	99.99
1.B.2.b	Natural Gas		CO2	3.07	0.25	0.000	0.00	100.00
2.C.1.	Iron and Steel Production		CH4	16.52	8.83	0.000	0.00	100.00
1.A.1.	Energy industries	Liquid fuels	CH4	3.02	2.50	0.000	0.00	100.00
4.D.2.	Land Converted to Wetlands		N2O	3.92		0.000	0.00	100.00
4.A.2.	Land Converted to Forest Land		N2O	0.15	0.91	0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH4	2.91	0.59	0.000	0.00	100.00
4.C.2.	Land Converted to Grassland		N2O	2.95		0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH4	0.16	0.71	0.000	0.00	100.00
1.A.3.c.	Railways		CH4	0.73	0.97	0.000	0.00	100.00
1.B.2.a	Oil		CO2	4.03	2.38	0.000	0.00	100.00
1.B.2.c	Venting and flaring		N2O	0.79	0.81	0.000	0.00	100.00
1.A.3.a.	Domestic Aviation		CH4	1.51	0.35	0.000	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	N2O	0.71	0.00	0.000	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	CH4	0.56		0.000	0.00	100.00
1.A.3.e.	Other transportation		CH4	0.22	0.02	0.000	0.00	100.00
1.A.3.e.	Other transportation		N2O	0.21	0.02	0.000	0.00	100.00
1.C.	CO2 Transport and storage		CO2	0.13	0.13	0.000	0.00	100.00
2.B.8.	Petrochemical and carbon black production		CH4	0.00	0.05	0.000	0.00	100.00
2.E.5.	Other		HFC	0.10		0.000	0.00	100.00
4.D.1.	Wetlands Remaining Wetlands		CO2		-0.03	0.000	0.00	100.00
2.E.5.	Other		PFC	0.01		0.000	0.00	100.00
	Total			**502 174.97**	**161 572.23**	**1.42**	**100.00**	

Table A5 Approach 1 Key category analysis trend assessment without LULUCF, 2022

	Category	Fuel	Gas	2022	1990	Trend	Cont	Cum.
1.A.1.	Energy industries	Solid fuels	CO2	115 999.22	26 244.22	0.227	13.69	13.69
1.A.4.	Other sectors	Gaseous fuels	CO2	46 168.72	93.89	0.201	12.15	25.84
3.A.	Enteric fermentation		CH4	38 243.90	29 996.47	0.154	9.31	35.16
1.A.2.	Manufacturing industries and construction	Solid fuels	CO2	25 581.49	22 199.68	0.126	7.61	42.77
1.A.3.b.	Road Transportation		CO2	84 698.25	24 142.97	0.112	6.77	49.54
1.A.4.	Other sectors	Liquid fuels	CO2	11 676.10	14 433.04	0.104	6.26	55.80
1.A.4.	Other sectors	Solid fuels	CO2	14 400.03	14 749.94	0.095	5.75	61.54
1.A.2.	Manufacturing industries and construction	Liquid fuels	CO2	13 839.81	13 246.53	0.082	4.92	66.46
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CO2	21 100.34	1 557.79	0.076	4.57	71.04
1.A.1.	Energy industries	Gaseous fuels	CO2	30 117.34	6 279.95	0.065	3.90	74.93
2.A.1.	Cement Production (Mineral Products)		CO2	40 006.67	10 444.54	0.063	3.82	78.75
3.D.1	Direct N2O emissions from managed soils		N2O	19 790.26	13 490.36	0.058	3.50	82.26
1.A.1.	Energy industries	Liquid fuels	CO2	8 568.03	7 066.65	0.038	2.31	84.57
2.C.1.	Iron and Steel Production		CO2	9 629.32	6 938.83	0.032	1.95	86.51
1.A.4.	Other sectors	Biomass	CH4	577.72	2 534.96	0.025	1.49	88.00
5.D.	Wastewater treatment and discharge		CH4	3 487.98	3 123.72	0.018	1.10	89.10
2.F.6.	Other applications		HFC	9 782.20		0.018	1.06	90.16
5.A.	Solid waste disposal		CH4	10 612.81	5 787.87	0.016	0.94	91.10
2.A.2.	Lime Production (Mineral Products)		CO2	2 272.29	2 248.73	0.014	0.86	91.96
1.B.1	Fugitive emissions from solid fuels		CH4	8 332.06	4 400.68	0.011	0.65	92.61
3.B.	Manure management		N2O	4 366.41	2 742.73	0.010	0.62	93.23
1.B.2.b	Fugitive emissions from fuels	Natural Gas	CH4	2 532.46	160.94	0.009	0.57	93.79
3.D.2	Indirect N2O Emissions from managed soils		N2O	2 527.49	1 900.74	0.009	0.56	94.35
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CO2	4 570.50		0.008	0.49	94.85
3.B.	Manure management		CH4	4 983.00	2 775.69	0.008	0.48	95.33
1.A.4.	Other sectors	Solid fuels	CH4	1 018.29	1 146.02	0.008	0.47	95.80
2.A.4.	Other process uses of carbonates		CO2	2 854.89	618.64	0.006	0.35	96.16
1.A.3.c.	Railways		CO2	456.71	651.19	0.005	0.30	96.46
1.A.3.a.	Domestic Aviation		CO2	3 334.88	913.74	0.005	0.29	96.75
2.C.3.	Aluminium Production		PFC	7.72	424.66	0.005	0.27	97.02
5.D.	Wastewater treatment and discharge		N2O	2 131.91	1 281.42	0.004	0.27	97.29
2.B.2.	Nitric acid production		N2O	1 580.39	945.85	0.003	0.19	97.48
1.A.4.	Other sectors	Biomass	N2O	72.90	319.89	0.003	0.19	97.67
1.B.2.a	Oil		CH4	478.44	470.26	0.003	0.18	97.85

Table A5 Approach 1 Key category analysis trend assessment without LULUCF, 2022 (cont'd)

	Category	Fuel	Gas	2022	1990	Trend	Cont	Cum.
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	62.73	282.87	0.003	0.17	98.01
2.A.3.	Glass Production		CO2	875.89	111.68	0.003	0.16	98.17
3.F.	Field burning of agricultural residues		CH4	146.54	296.94	0.003	0.15	98.33
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO2	1 072.82	220.75	0.002	0.14	98.47
1.A.4.	Other sectors	Liquid fuels	N2O	1 011.18	615.52	0.002	0.13	98.60
1.A.1.	Energy industries	Solid fuels	N2O	697.17	86.21	0.002	0.13	98.73
2.C.6.	Zinc Production		CO2	508.46	37.84	0.002	0.11	98.84
1.A.1.	Energy industries	Gaseous fuels	N2O	358.39	2.74	0.002	0.09	98.93
1.A.3.e.	Other transportation		CO2	438.27	39.29	0.002	0.09	99.02
2.B.1.	Ammonia Production		CO2	701.41	424.76	0.001	0.09	99.11
1.B.2.c	Venting and flaring		CO2	210.54	217.58	0.001	0.09	99.20
2.D.1.	Lubricant Use		CO2	138.99	175.11	0.001	0.08	99.27
1.B.2.c	Venting and flaring		CH4	616.72	142.23	0.001	0.07	99.34
2.B.7.	Soda ash production		CO2	653.48		0.001	0.07	99.41
2.B.8.	Petrochemical and carbon black production		CO2	1.25	81.49	0.001	0.05	99.47
1.A.3.b.	Road Transportation		CH4	459.35	108.07	0.001	0.05	99.52
5.C.	Incineration and open burning of waste		CH4	5.65	74.12	0.001	0.05	99.56
2.F.3.	Fire protection		HFC	401.76		0.001	0.04	99.61
3.F.	Field burning of agricultural residues		N2O	35.96	72.86	0.001	0.04	99.65
2.B.5.	Carbide production		CO2	7.92	58.99	0.001	0.04	99.68
2.C.3.	Aluminium Production		CO2	117.74	99.16	0.001	0.03	99.71
1.A.4.	Other sectors	Gaseous fuels	CH4	116.01	0.24	0.001	0.03	99.75
1.A.3.c.	Railways		N2O	47.89	61.10	0.000	0.03	99.77
1.A.3.b.	Road Transportation		N2O	1 250.61	478.17	0.000	0.02	99.79
1.A.4.	Other sectors	Solid fuels	N2O	58.33	54.25	0.000	0.02	99.81
1.A.4.	Other sectors	Liquid fuels	CH4	20.34	34.51	0.000	0.02	99.83
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	96.88	64.56	0.000	0.02	99.85
5.C.	Incineration and open burning of waste		CO2	5.35	26.14	0.000	0.02	99.86
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	68.38	45.74	0.000	0.01	99.87
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	22.54	26.78	0.000	0.01	99.88
2.G.1.	Electrical equipment		SF6	93.58		0.000	0.01	99.89
2.E.5.	Other		SF6	70.78		0.000	0.01	99.90
1.A.1.	Energy industries	Biomass	N2O	67.27		0.000	0.01	99.91
1.A.1.	Energy industries	Other fossil fuels	CO2	65.15		0.000	0.01	99.92

Table A5 Approach 1 Key category analysis trend assessment without LULUCF, 2022 (cont'd)

	Category	Fuel	Gas	2022	1990	Trend	Cont	Cum.
2.C.2.	Ferroalloys Production		CO2	124.85	61.56	0.000	0.01	99.92
5.C.	Incineration and open burning of waste		N2O	0.78	9.82	0.000	0.01	99.93
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	12.02	14.18	0.000	0.01	99.94
1.A.4.	Other sectors	Gaseous fuels	N2O	21.96	0.04	0.000	0.01	99.94
1.A.2.	Manufacturing industries and construction	Biomass	N2O	50.10		0.000	0.01	99.95
2.C.4.	Magnesium Production		SF6	43.99		0.000	0.00	99.95
1.A.2.	Manufacturing industries and construction	Biomass	CH4	39.70		0.000	0.00	99.96
1.A.1.	Energy industries	Liquid fuels	N2O	5.57	8.84	0.000	0.00	99.96
1.A.1.	Energy industries	Gaseous fuels	CH4	21.20	2.90	0.000	0.00	99.96
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	33.88		0.000	0.00	99.97
3.H.	Urea application		CO2	1 138.12	459.95	0.000	0.00	99.97
2.D.2.	Paraffin Wax Use		CO2	8.93	8.25	0.000	0.00	99.97
1.A.3.a.	Domestic Aviation		N2O	30.51	7.90	0.000	0.00	99.98
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	26.85		0.000	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	10.60	0.79	0.000	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	10.04	0.74	0.000	0.00	99.98
1.A.1.	Energy industries	Solid fuels	CH4	23.03	6.51	0.000	0.00	99.99
5.B.	Biological treatment of solid waste		CH4	13.00	8.16	0.000	0.00	99.99
3.C.	Rice cultivation		CH4	279.87	112.09	0.000	0.00	99.99
2.C.1.	Iron and Steel Production		CH4	16.52	8.83	0.000	0.00	99.99
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	0.43	1.91	0.000	0.00	99.99
1.A.1.	Energy industries	Biomass	CH4	10.16		0.000	0.00	99.99
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N2O	7.87	1.59	0.000	0.00	99.99
5.B.	Biological treatment of solid waste		N2O	7.38	4.63	0.000	0.00	100.00
2.C.5.	Lead Production		CO2	9.08	2.20	0.000	0.00	100.00
1.A.1.	Energy industries	Liquid fuels	CH4	3.02	2.50	0.000	0.00	100.00
1.B.2.b	Natural Gas		CO2	3.07	0.25	0.000	0.00	100.00
1.B.2.a	Oil		CO2	4.03	2.38	0.000	0.00	100.00
1.A.3.c.	Railways		CH4	0.73	0.97	0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH4	0.16	0.71	0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH4	2.91	0.59	0.000	0.00	100.00
1.B.2.c	Venting and flaring		N2O	0.79	0.81	0.000	0.00	100.00
1.A.3.a.	Domestic Aviation		CH4	1.51	0.35	0.000	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	N2O	0.71		0.000	0.00	100.00

Table A5 Approach 1 Key category analysis trend assessment without LULUCF, 2022 (cont'd)

	Category	Fuel	Gas	2022	1990	Trend	Cont	Cum.
1.A.1.	Energy industries	Other fossil fuels	CH4	0.56		0.000	0.00	100.00
1.C.	CO2 Transport and storage		CO2	0.13	0.13	0.000	0.00	100.00
1.A.3.e.	Other transportation		CH4	0.22	0.02	0.000	0.00	100.00
1.A.3.e.	Other transportation		N2O	0.21	0.02	0.000	0.00	100.00
2.B.8.	Petrochemical and carbon black production		CH4		0.05	0.000	0.00	100.00
2.E.5.	Other		HFC	0.10		0.000	0.00	100.00
2.E.5.	Other		PFC	0.01		0.000	0.00	100.00
	Total			**558 270.48**	**228 001.91**	**1.66**	**100.00**	

Table A6 Approach 2 Key category analysis level assessment without LULUCF, 2022

	Category	Fuel	GAS	2022 Emissions	2022 Absolute Emissions	Combined Unc. (%)	$LU_{x,t}$ (%)	Cumulative total of $LU_{x,t}$ (%)
3.D.1	Direct N2O emissions from agricultural soils		N2O	19 790	19 790	105.7	19.45	19.45
1.B.1.a.	Coal mining and handling		CH4	8 332	8 332	150.9	11.70	31.15
1.A.3.b	Road Transportation		CO2	84 698	84 698	8.9	7.00	38.15
3.A.	Enteric fermentation		CH4	38 244	38 244	14.9	5.31	43.45
1.A.2	Manufacturing industries and construction	Solid fuels	CO2	25 581	25 581	17.5	4.16	47.62
1.A.1	Energy Industries	Solid fuels	CO2	115 999	115 999	3.4	3.70	51.32
5.A	Solid waste disposal		CH4	10 613	10 613	37.2	3.67	54.99
1.A.2	Manufacturing industries and construction	Gaseous fuels	CO2	21 100	21 100	18.4	3.61	58.60
1.A.2	Manufacturing industries and construction	Liquid fuels	CO2	13 840	13 840	26.8	3.44	62.04
3.D.2	Indirect N2O emissions from agricultural soils		N2O	2 527	2 527	143.9	3.38	65.43
1.A.4	Other sectors	Gaseous fuels	CO2	46 169	46 169	6.8	2.92	68.34
1.B.2.b.	Fugitive emissions from fuels	Natural gas	CH4	2 532	2 532	100.2	2.36	70.70
1.A.4	Other sectors	Liquid fuels	N2O	1 011	1 011	250.1	2.35	73.06
2.F.6.	Other applications		HFC	9 782	9 782	25.5	2.32	75.38
1.A.3.b	Road Transportation		N2O	1 251	1 251	196.9	2.29	77.67
3.B.	Manure management		N2O	4 366	4 366	52.0	2.11	79.78
2.A.1.	Cement Production (Mineral Products)		CO2	40 007	40 007	5.4	2.00	81.78
1.A.4	Other sectors	Solid fuels	CO2	14 400	14 400	13.2	1.76	83.54
1.A.4	Other sectors	Biomass	CH4	578	578	316.2	1.70	85.24
3.B.	Manure management		CH4	4 983	4 983	33.1	1.54	86.78
1.A.4	Other sectors	Liquid fuels	CO2	11 676	11 676	12.4	1.35	88.13
2.C.1.	Iron and Steel Production		CO2	9 629	9 629	12.8	1.15	89.28
5.D.1	Wastewater treatment and discharge		N2O	2 132	2 132	51.9	1.03	90.31
5.D	Wastewater treatment and discharge		CH4	3 488	3 488	30.8	1.00	91.31
1.A.4	Other sectors	Solid fuels	CH4	1 018	1 018	100.3	0.95	92.26
2.A.4.	Other process uses of carbonates		CO2	2 855	2 855	30.1	0.80	93.05
1.A.3.b	Road Transportation		CH4	459	459	158.0	0.68	93.73
1.B.2.c.	Venting and flaring		CH4	617	617	100.2	0.58	94.30
3.H.	Urea application		CO2	1 138	1 138	51.0	0.54	94.84
1.A.1	Energy Industries	Solid fuels	N2O	697	697	74.9	0.49	95.33
1.A.1	Energy Industries	Liquid fuels	CO2	8 568	8 568	5.7	0.45	95.78
1.B.2.a.	Oil		CH4	478	478	100.2	0.45	96.23

Table A7 Approach 2 Key category analysis trend assessment without LULUCF, 2022

	Category	Fuel	GAS	1990 Emissions	2022 Emissions	Combined Unc. (%)	$TU_{x,t}$	Cont. of $TU_{x,t}$ (%)	Cumulative total of $TU_{x,t}$ (%)
1.A.4	Other sectors	Biomass	CH4	2 535	578	316.2	0.0781	19.49	19.49
3.D.1	Direct N2O emissions from agricultural soils		N2O	13 490	19 790	105.7	0.0614	15.32	34.80
3.A.	Enteric fermentation		CH4	29 996	38 244	14.9	0.0230	5.75	40.55
1.A.2	Manufacturing industries and construction	Solid fuels	CO2	22 200	25 581	17.5	0.0221	5.51	46.06
1.A.2	Manufacturing industries and construction	Liquid fuels	CO2	13 247	13 840	26.8	0.0218	5.45	51.51
1.B.1.a.	Coal mining and handling		CH4	4 401	8 332	150.9	0.0162	4.04	55.54
1.A.2	Manufacturing industries and construction	Gaseous fuels	CO2	1 558	21 100	18.4	0.0139	3.48	59.02
1.A.4	Other sectors	Gaseous fuels	CO2	94	46 169	6.8	0.0137	3.42	62.44
3.D.2	Indirect N2O emissions from agricultural soils		N2O	1 901	2 527	143.9	0.0134	3.35	65.79
1.A.4	Other sectors	Liquid fuels	CO2	14 433	11 676	12.4	0.0129	3.21	69.00
1.A.4	Other sectors	Solid fuels	CO2	14 750	14 400	13.2	0.0125	3.13	72.13
1.A.3.b	Road Transportation		CO2	24 143	84 698	8.9	0.0100	2.49	74.61
1.A.4	Other sectors	Biomass	N2O	320	73	316.2	0.0099	2.46	77.07
1.B.2.b.	Fugitive emissions from fuels	Natural gas	CH4	161	2 532	100.2	0.0094	2.35	79.42
1.A.4	Other sectors	Solid fuels	CH4	1 146	1 018	100.3	0.0079	1.96	81.38
1.A.1	Energy Industries	Solid fuels	CO2	26 244	115 999	3.4	0.0078	1.94	83.32
5.A	Solid waste disposal		CH4	5 788	10 613	37.2	0.0058	1.45	84.77
5.D	Wastewater treatment and discharge		CH4	3 124	3 488	30.8	0.0056	1.40	86.18
1.A.4	Other sectors	Liquid fuels	N2O	616	1 011	250.1	0.0054	1.36	87.53
3.B.	Manure management		N2O	2 743	4 366	52.0	0.0054	1.34	88.87
2.F.6.	Other applications		HFC		9 782	25.5	0.0045	1.11	89.99
2.C.1.	Iron and Steel Production		CO2	6 939	9 629	12.8	0.0041	1.03	91.02
2.A.1.	Cement Production (Mineral Products)		CO2	10 445	40 007	5.4	0.0034	0.85	91.87
1.B.2.a.	Oil		CH4	470	478	100.2	0.0030	0.74	92.61
3.B.	Manure management		CH4	2 776	4 983	33.1	0.0026	0.66	93.26
5.D.1	Wastewater treatment and discharge		N2O	1 281	2 132	51.9	0.0023	0.57	93.84
1.A.1	Energy Industries	Liquid fuels	CO2	7 067	8 568	5.7	0.0022	0.54	94.38
2.A.4.	Other process uses of carbonates		CO2	619	2 855	30.1	0.0018	0.44	94.82
3.F.	Field burning of agricultural residues		CH4	297	147	64.0	0.0016	0.41	95.22
1.A.1	Energy Industries	Solid fuels	N2O	86	697	74.9	0.0016	0.40	95.62
2.A.2.	Lime Production (Mineral Products)		CO2	2 249	2 272	10.2	0.0014	0.36	95.98
1.A.3.b	Road Transportation		CH4	108	459	158.0	0.0013	0.34	96.32

Annex 2: Uncertainty

Turkish Statistical Institute has undertaken Approach 1 uncertainty analysis. Approach 1 is based on equations for error propagation. In the IPCC Good Practice Guidance, two methodologies (Tier 1 and Tier 2) for combining uncertainties are defined. Tier 1 uses error propagation equations. The equations are appropriate, when uncertainties are relatively small, have normal distributions and have no significant covariance. The country considered the uncertainy results for prioritizing category improvements. Especially sectors with large AD or EF uncertainties, even if they are not key categories, have been treated as key categories and more precise information has been collected on those sub-categories primarily. Table A8 presents Approach 1 (Propagation of Error) uncertainty results using Table 3.2 of Volume 1 of the 2006 IPCC Guidelines for the current submission.

According to the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Emission Inventories, quality control is "a system of routine technical activities, to measure and control the quality of the inventory as it is being developed". The QC system is designed to provide routine and consistent checks to ensure data integrity, correctness and completeness, to identify and address errors and emissions and to document and archive inventory material and record all QC activities. And, for the categories with a high uncertainty, generally, further improvements are planned whenever sectoral studies can be carried out.

Table A8 Approach 1 Uncertainty assessment

Source Category		Fuel	Gas	Emissions in 1990 Gg CO_2 eq	Emissions in 2022 Gg CO_2 eq	AD Unc. %	EF Unc. %	Combined Unc. %	H(1) %	I(2) %	J(3) %	K(4) %	L(5) %	M(6) %
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CO2	3 650.2	2 018.2	1.0	4.1	4.2	0.0	0.1	0.0	0.2	0.0	0.1
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CO2	24 147.7	113 710.0	1.0	3.4	3.5	0.6	0.2	0.7	0.8	1.0	1.6
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CO2	5 024.7	28 054.7	1.0	1.1	1.5	0.0	0.1	0.2	0.1	0.2	0.1
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CO2		65.2	18.0	9.6	20.4	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.b.	Petroleum Refining	Liquid fuels	CO2	3 401.8	6 549.8	2.0	7.0	7.3	0.0	0.0	0.0	0.2	0.1	0.0
1.A.1.b.	Petroleum Refining	Solid fuels	CO2	114.5	213.9	2.0	7.0	7.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	CO2	1 255.3	2 062.6	2.0	7.0	7.3	0.0	0.0	0.0	0.1	0.0	0.0
1.A.1.c.	Manufacture of solid fuels	Liquid fuels	CO2	14.7		2.0	7.0	7.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CO2	1 982.0	2 075.3	2.0	7.0	7.3	0.0	0.0	0.0	0.2	0.0	0.0
1.A.2.a.	Iron and Steel Production	Liquid fuels	CO2	1 823.3	66.6	10.0	7.0	12.2	0.0	0.0	0.0	0.2	0.0	0.1
1.A.2.a.	Iron and Steel Production	Solid fuels	CO2	4 854.8	1 682.4	10.0	7.0	12.2	0.0	0.1	0.0	0.6	0.1	0.4
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CO2		3 399.2	10.0	7.0	12.2	0.0	0.0	0.0	0.1	0.3	0.1
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CO2	927.8	15.1	21.2	7.0	22.3	0.0	0.0	0.0	0.1	0.0	0.0
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CO2	156.3	274.0	21.2	7.0	22.3	0.0	0.0	0.0	0.0	0.1	0.0
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CO2		578.5	21.2	7.0	22.3	0.0	0.0	0.0	0.0	0.1	0.0
1.A.2.c.	Chemicals	Liquid fuels	CO2	2 588.1	52.0	15.8	7.0	17.3	0.0	0.0	0.0	0.3	0.0	0.1
1.A.2.c.	Chemicals	Solid fuels	CO2	1 342.6	2 262.1	15.8	7.0	17.3	0.0	0.0	0.0	0.1	0.3	0.1
1.A.2.c.	Chemicals	Gaseous fuels	CO2	944.6	5 484.1	15.8	7.0	17.3	0.0	0.0	0.0	0.1	0.8	0.6
1.A.2.c.	Chemicals	Other fossil fuels	CO2		0.5	2.0	7.0	7.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CO2		22.4	18.0	7.0	19.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CO2		988.9	18.0	7.0	19.3	0.0	0.0	0.0	0.0	0.2	0.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CO2		337.3	18.0	7.0	19.3	0.0	0.0	0.0	0.0	0.1	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CO2	420.7	82.0	5.0	7.0	8.6	0.0	0.0	0.0	0.1	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CO2	2 471.7	4 066.8	18.0	7.0	19.3	0.0	0.0	0.0	0.2	0.6	0.4
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CO2		2 303.5	14.1	7.0	15.8	0.0	0.0	0.0	0.1	0.3	0.1
1.A.2.f.	Non-metallic minerals	Liquid fuels	CO2	2 626.3	12 734.7	27.8	7.0	28.7	0.5	0.0	0.1	0.2	3.1	9.6
1.A.2.f.	Non-metallic minerals	Solid fuels	CO2	5 587.5	12 097.8	25.5	7.0	26.4	0.4	0.0	0.1	0.2	2.7	7.3
1.A.2.f.	Non-metallic minerals	Gaseous fuels	CO2	1.9	4 055.1	29.2	7.0	30.0	0.1	0.0	0.0	0.2	1.0	1.1
1.A.2.f.	Non-metallic minerals	Other fossil fuels	CO2		4 570.0	2.0	7.0	7.3	0.0	0.0	0.0	0.2	0.1	0.0
1.A.2.g.	Other Industries	Liquid Fuels	CO2	4 860.3	866.9	70.7	7.0	71.1	0.0	0.1	0.0	0.6	0.5	0.7
1.A.2.g.	Other Industries	Solid Fuels	CO2	7 786.9	4 209.5	70.7	7.0	71.1	0.4	0.1	0.0	0.9	2.6	7.5
1.A.2.g.	Other Industries	Gaseous Fuels	CO2	611.2	4 942.7	70.7	7.0	71.1	0.5	0.0	0.0	0.1	3.1	9.4
1.A.3.a.	Domestic Aviation	Jet kerosene	CO2	913.7	3 334.9	5.5	5.0	7.4	0.0	0.0	0.0	0.0	0.2	0.0
1.A.3.b.	Road Transportation	Gasoline	CO2	8 377.4	9 636.9	10.1	5.0	11.2	0.0	0.1	0.1	0.5	0.8	1.0
1.A.3.b.	Road Transportation	Diesel oil	CO2	15 765.5	65 652.4	10.1	5.0	11.2	2.2	0.1	0.4	0.5	5.8	33.6

Table A8 Approach 1 Uncertainty assessment (cont'd)

Source	Category	Fuel	Gas	Emissions in 1990	Emissions in 2022	AD Unc.	EF Unc.	Combined Unc.	H(1)	I(2)	J(3)	K(4)	L(5)	M(6)
				Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
1.A.3.b.	Road Transportation	LPG	CO_2		9 243.7	10.1	5.0	11.2	0.0	0.1	0.1	0.3	0.8	0.7
1.A.3.b.	Road Transportation	Gaseous fuels	CO_2		165.2	10.0	7.0	12.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.c.	Railways	Liquid fuels	CO_2	589.5	456.7	2.0	1.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.c.	Railways	Solid fuels	CO_2	61.7		14.1	14.0	19.9	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO_2	282.9	62.7	15.0	3.0	15.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO_2	220.8	1 072.8	15.0	1.5	15.1	0.0	0.0	0.0	0.0	0.1	0.0
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CO_2	39.3	438.3	5.0	7.0	8.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a.	Commercial/institutional	Liquid fuels	CO_2	5 447.0	1 035.6	7.1	7.0	10.0	0.0	0.1	0.0	0.7	0.1	0.5
1.A.4.a.	Commercial/institutional	Solid fuels	CO_2	4 163.9	2 656.5	14.1	7.0	15.7	0.0	0.1	0.0	0.4	0.3	0.3
1.A.4.a.	Commercial/institutional	Gaseous fuels	CO_2	21.3	11 296.3	5.0	7.0	8.6	0.0	0.1	0.1	0.5	0.5	0.5
1.A.4.b.	Residential	Liquid fuels	CO_2	3 216.4	1 009.0	7.1	7.0	10.0	0.0	0.1	0.0	0.4	0.1	0.2
1.A.4.b.	Residential	Solid fuels	CO_2	10 586.1	11 743.5	14.1	7.0	15.7	0.1	0.1	0.1	0.9	1.4	2.9
1.A.4.b.	Residential	Gaseous fuels	CO_2	72.6	34 656.3	5.0	7.0	8.6	0.4	0.2	0.2	1.5	1.5	4.5
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CO_2	5 769.6	9 631.5	14.1	5.0	15.0	0.1	0.1	0.1	0.3	1.2	1.5
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CO_2		216.2	7.0	7.0	9.9	0.0	0.0	0.0	0.0	0.0	0.0
1.B.2.a.	Oil		CO_2	2.4	4.0	7.0	50.0	50.5	0.0	0.0	0.0	0.0	0.0	0.0
1.B.2.b.	Natural gas		CO_2	0.3	3.1	7.0	50.0	50.5	0.0	0.0	0.0	0.0	0.0	0.0
1.B.2.c.	Venting and flaring		CO_2	217.6	210.5	7.0	50.0	50.5	0.0	0.0	0.0	0.1	0.0	0.0
1.C	Transport of CO2		CO_2	0.1	0.1	2.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0
2.A.1.	Cement Production (Mineral Products)		CO_2	10 444.5	40 006.7	5.0	2.0	5.4	0.2	0.0	0.2	0.1	1.8	3.1
2.A.2.	Lime Production (Mineral Products)		CO_2	2 248.7	2 272.3	10.0	2.0	10.2	0.0	0.0	0.0	0.1	0.2	0.0
2.A.3.	Glass Production		CO_2	111.7	875.9	3.0	2.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0
2.A.4.	Other process uses of carbonates		CO_2	618.6	2 854.9	30.0	2.0	30.1	0.0	0.0	0.0	0.0	0.7	0.6
2.B.1.	Ammonia Production		CO_2	424.8	701.4	2.0	5.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0
2.B.5.	Carbide production		CO_2	59.0	7.9	5.0	20.0	20.6	0.0	0.0	0.0	0.0	0.0	0.0
2.B.7.	Soda ash production		CO_2		653.5	5.0	1.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0
2.B.8.	Petrochemical and carbon black production		CO_2	81.5	1.2	10.0	10.0	14.1	0.0	0.0	0.0	0.0	0.0	0.0
2.C.1.	Iron and Steel Production		CO_2	6 938.8	9 629.3	10.0	8.0	12.8	0.1	0.1	0.1	0.6	0.8	1.1
2.C.2.	Ferroalloys Production		CO_2	61.6	124.9	5.0	25.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
2.C.3.	Aluminium Production		CO_2	99.2	117.7	1.0	5.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0
2.C.5.	Lead Production		CO_2	2.2	9.1	25.0	20.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0
2.C.6.	Zinc Production		CO_2	37.8	508.5	5.0	50.0	50.2	0.0	0.0	0.0	0.1	0.0	0.0
2.D.1.	Lubricant Use		CO_2	175.1	139.0	20.0	50.0	53.9	0.0	0.0	0.0	0.1	0.0	0.0
2.D.2.	Paraffin Wax Use		CO_2	8.3	8.9	20.0	100.0	102.0	0.0	0.0	0.0	0.0	0.0	0.0
3.H.	Urea application		CO_2	459.9	1 138.1	10.0	50.0	51.0	0.0	0.0	0.0	0.1	0.1	0.0

Table A8 Approach 1 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990	Emissions in 2022	AD Unc.	EF Unc.	Combined Unc.	H(1)	I(2)	J(3)	K(4)	L(5)	M(6)
				Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
4.A.	Forest land		CO_2	-63 624.5	-44 865.6	75.7	4.5	75.8	45.9	0.9	0.3	4.3	29.7	901.5
4.B.	Cropland		CO_2		548.9	47.9	4.2	48.0	0.0	0.0	0.0	0.0	0.2	0.1
4.C.	Grassland		CO_2		625.5	148.7	10.2	149.0	0.0	0.0	0.0	0.0	0.8	0.7
4.D.	Wetlands		CO_2	0.0	- 101.6	85.9	3.9	86.0	0.0	0.0	0.0	0.0	0.1	0.0
4.E.	Settlements		CO_2		509.2	25.7	4.0	26.0	0.0	0.0	0.0	0.0	0.1	0.0
4.F.	Other land		CO_2		734.7	15.6	3.8	16.0	0.0	0.0	0.0	0.0	0.1	0.0
4.G.	Harvested wood products		CO_2	-2 947.7	-13 688.7	23.3	3.2	23.5	0.4	0.0	0.1	0.1	2.8	7.8
5.C.	Incineration and open burning of waste		CO_2	26.1	5.3	30.4	40.0	50.2	0.0	0.0	0.0	0.0	0.0	0.0
	Total CO_2			**87 568.4**	**385 185.3**									
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CH_4	1.3	0.7	6.0	25.0	25.7	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CH_4	6.0	22.4	1.0	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CH_4	2.4	20.5	3.0	25.0	25.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CH_4		0.6	0.9	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.a.	Public Electricity and Heat Production	Biomass	CH_4		10.2	0.9	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.b.	Petroleum Refining	Liquid fuels	CH_4	1.2	2.4	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.b.	Petroleum Refining	Solid fuels	CH_4	0.1	0.2	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	CH_4	0.5	0.7	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.c.	Manufacture of solid fuels	Liquid fuels	CH_4	0.0		2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CH_4	0.4	0.4	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.a.	Iron and Steel Production	Liquid fuels	CH_4	2.0	0.1	10.0	100.0	100.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.a.	Iron and Steel Production	Solid fuels	CH_4	0.8	0.5	10.0	100.0	100.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CH_4		1.7	10.0	100.0	100.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.a.	Iron and Steel Production	Biomass	CH_4		0.1	10.0	100.0	100.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CH_4	1.0	0.0	21.2	100.0	102.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CH_4	0.4	0.8	21.2	100.0	102.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CH_4		0.3	21.2	100.0	102.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b.	Non-Ferrous Metals	Biomass	CH_4		0.0	15.8	100.0	101.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c.	Chemicals	Liquid fuels	CH_4	2.9	0.0	15.8	100.0	101.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c.	Chemicals	Solid fuels	CH_4	3.3	6.5	15.8	100.0	101.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c.	Chemicals	Gaseous fuels	CH_4	0.5	2.8	15.8	100.0	101.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c.	Chemicals	Other fossil fuels	CH_4		0.0	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c.	Chemicals	Biomass	CH_4		0.1	15.8	100.0	101.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CH_4		0.0	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0

Table A8 Approach 1 Uncertainty assessment (cont'd)

Source	Category	Fuel	Gas	Emissions in 1990	Emissions in 2022	AD Unc.	EF Unc.	Combined Unc.	H(1)	I(2)	J(3)	K(4)	L(5)	M(6)
				Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CH_4		2.7	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CH_4		0.2	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d.	Pulp, Paper and Print	Biomass	CH_4		0.3	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CH_4	0.5	0.1	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CH_4	6.2	11.2	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CH_4		1.2	14.1	100.0	101.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	CH_4		0.9	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f.	Non-metallic minerals	Liquid fuels	CH_4	2.6	11.1	27.8	100.0	103.8	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f.	Non-metallic minerals	Solid fuels	CH_4	15.2	34.8	25.5	100.0	103.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f.	Non-metallic minerals	Gaseous fuels	CH_4	0.0	2.0	29.2	100.0	104.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f.	Non-metallic minerals	Other fossil fuels	CH_4		26.8	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f.	Non-metallic minerals	Biomass	CH_4		24.2	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g.	Other Industries	Liquid Fuels	CH_4	5.2	0.7	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g.	Other Industries	Solid Fuels	CH_4	19.9	11.8	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g.	Other Industries	Gaseous Fuels	CH_4	0.3	2.5	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g.	Other Industries	Biomass	CH_4		14.1	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.a.	Domestic Aviation	Jet kerosene	CH_4	0.3	1.5	5.5	80.0	80.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b.	Road Transportation	Gasoline	CH_4	84.6	97.3	10.0	250.0	250.2	0.0	0.0	0.0	0.3	0.0	0.1
1.A.3.b.	Road Transportation	Diesel oil	CH_4	23.4	99.2	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b.	Road Transportation	Liquefied petroleum gases (LPG)	CH_4		254.4	10.0	250.0	250.2	0.0	0.0	0.0	0.4	0.0	0.2
1.A.3.b.	Road Transportation	Gaseous fuels	CH_4		7.6	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b.	Road Transportation	Biomass	CH_4		0.7	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.c.	Railways	Liquid fuels	CH_4	0.9	0.7	5.0	105.0	105.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.c.	Railways	Solid fuels	CH_4	0.0		5.0	135.0	135.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH_4	0.7	0.2	15.0	50.0	52.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH_4	0.6	2.9	15.0	50.0	52.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CH_4	0.0	0.2	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a.	Commercial/institutional	Liquid fuels	CH_4	13.6	2.6	7.1	100.0	100.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a.	Commercial/institutional	Solid fuels	CH_4	7.0	7.4	14.1	100.0	101.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a.	Commercial/institutional	Gaseous fuels	CH_4	0.1	28.4	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.b.	Residential	Liquid fuels	CH_4	11.6	2.2	7.1	100.0	100.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.b.	Residential	Solid fuels	CH_4	1 139.0	1 010.9	14.1	100.0	101.0	0.0	0.0	0.0	1.6	0.1	2.5
1.A.4.b.	Residential	Gaseous fuels	CH_4	0.2	87.1	5.0	100.0	100.1	0.0	0.0	0.0	0.1	0.0	0.0
1.A.4.b.	Residential	Biomass	CH_4	2 535.0	577.7	300.0	100.0	316.2	0.1	0.0	0.0	4.5	1.5	22.7
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CH_4	9.3	15.5	200.0	250.0	320.2	0.0	0.0	0.0	0.0	0.0	0.0

Table A8 Approach 1 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 Gg CO_2 eq	Emissions in 2022 Gg CO_2 eq	AD Unc. %	EF Unc. %	Combined Unc. %	H(1) %	I(2) %	J(3) %	K(4) %	L(5) %	M(6) %
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CH_4		0.5	7.0	100.0	100.2	0.0	0.0	0.0	0.0	0.0	0.0
1.B.1.a.	Coal mining and handling		CH_4	4 400.7	8 332.1	16.6	150.0	150.9	6.3	0.0	0.1	5.0	1.2	26.1
1.B.2.a.	Oil		CH_4	470.3	478.4	7.0	100.0	100.2	0.0	0.0	0.0	0.6	0.0	0.4
1.B.2.b.	Natural gas		CH_4	160.9	2 532.5	7.0	100.0	100.2	0.3	0.0	0.0	1.3	0.2	1.6
1.B.2.c.	Venting and flaring		CH_4	142.2	616.7	7.0	100.0	100.2	0.0	0.0	0.0	0.1	0.0	0.0
2.B.8.	Petrochemical and carbon black production		CH_4	0.1		10.0	30.0	31.6	0.0	0.0	0.0	0.0	0.0	0.0
2.C.1.	Iron and Steel Production		CH_4	8.8	16.5	10.0	5.0	11.2	0.0	0.0	0.0	0.0	0.0	0.0
3.A.	Enteric fermentation		CH_4	29 996.5	38 243.9	8.8	12.0	14.9	1.3	0.3	0.2	4.1	3.0	25.4
3.B.	Manure management		CH_4	2 775.7	4 983.0	14.1	30.0	33.1	0.1	0.0	0.0	0.7	0.6	0.8
3.C.	Rice cultivation		CH_4	112.1	279.9	5.0	76.8	76.9	0.0	0.0	0.0	0.0	0.0	0.0
3.F.	Field burning of agricultural residues		CH_4	296.9	146.5	50.0	40.0	64.0	0.0	0.0	0.0	0.2	0.1	0.0
4.A.	Forest land		CH_4	94.2	72.5	23.5	1.7	23.6	0.0	0.0	0.0	0.0	0.0	0.0
5.A.1.	Managed waste disposal		CH_4		2 673.9	10.0	30.8	32.4	0.0	0.0	0.0	0.5	0.2	0.3
5.A.2.	Unmanaged waste disposal sites		CH_4	5 787.9	7 938.9	30.0	38.1	48.5	0.6	0.1	0.0	2.4	2.1	10.0
5.B.	Biological treatment of solid waste		CH_4	8.2	13.0	10.0	20.0	22.4	0.0	0.0	0.0	0.0	0.0	0.0
5.C.	Incineration and open burning of waste		CH_4	74.1	5.7	30.4	100.0	104.5	0.0	0.0	0.0	0.1	0.0	0.0
5.D.1	Domestic wastewater		CH_4	2 889.4	2 701.1	5.0	37.7	38.0	0.0	0.0	0.0	1.5	0.1	2.2
5.D.2	Industrial wastewater		CH_4	234.4	786.9	11.2	39.1	40.7	0.0	0.0	0.0	0.0	0.1	0.0
	Total CH_4		**CO_2 eq**	**51 351.3**	**72 234.2**									
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	N_2O	7.5	2.7	6.0	75.0	75.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	N_2O	84.6	696.4	1.0	75.0	75.0	0.0	0.0	0.0	0.2	0.0	0.0
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	N_2O	2.3	357.7	3.0	75.0	75.1	0.0	0.0	0.0	0.2	0.0	0.0
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	N_2O		0.7	0.9	75.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.a.	Public Electricity and Heat Production	Biomass	N_2O		67.3	0.9	75.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.b.	Petroleum Refining	Liquid fuels	N_2O	1.3	2.8	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.b.	Petroleum Refining	Solid fuels	N_2O	0.2	0.4	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	N_2O	0.5	0.7	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.c.	Manufacture of solid fuels	Liquid fuels	N_2O	0.0		10.0	100.0	100.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	N_2O	1.4	0.4	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.a.	Iron and Steel Production	Liquid fuels	N_2O	3.8	0.1	10.0	100.0	100.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.a.	Iron and Steel Production	Solid fuels	N_2O	0.7	0.5	10.0	100.0	100.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.a.	Iron and Steel Production	Gaseous fuels	N_2O		1.6	10.0	100.0	100.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.a.	Iron and Steel Production	Biomass	N_2O		0.1	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A8 Approach 1 Uncertainty assessment (cont'd)

Source	Category	Fuel	Gas	Emissions in 1990	Emissions in 2022	AD Unc.	EF Unc.	Combined Unc.	H[1]	I[2]	J[3]	K[4]	L[5]	M[6]
				Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	N_2O	1.9	0.0	21.2	100.0	102.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b.	Non-Ferrous Metals	Solid fuels	N_2O	0.6	1.1	21.2	100.0	102.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	N_2O		0.3	21.2	100.0	102.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b.	Non-Ferrous Metals	Biomass	N_2O		0.0	21.2	100.0	102.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c.	Chemicals	Liquid fuels	N_2O	5.4	0.1	15.8	100.0	101.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c.	Chemicals	Solid fuels	N_2O	4.7	9.3	15.8	100.0	101.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c.	Chemicals	Gaseous fuels	N_2O	0.5	2.6	15.8	100.0	101.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c.	Chemicals	Other fossil fuels	N_2O		0.0	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c.	Chemicals	Biomass	N_2O		0.2	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	N_2O		0.0	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d.	Pulp, Paper and Print	Solid fuels	N_2O		3.9	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	N_2O		0.2	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d.	Pulp, Paper and Print	Biomass	N_2O		0.4	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	N_2O	0.9	0.1	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	N_2O	8.8	15.9	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	N_2O		1.1	14.1	100.0	101.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	N_2O		1.1	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f.	Non-metallic minerals	Liquid fuels	N_2O	5.0	20.9	27.8	100.0	103.8	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f.	Non-metallic minerals	Solid fuels	N_2O	21.6	49.4	25.5	100.0	103.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f.	Non-metallic minerals	Gaseous fuels	N_2O	0.0	1.9	29.2	100.0	104.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f.	Non-metallic minerals	Other fossil fuels	N_2O		33.9	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f.	Non-metallic minerals	Biomass	N_2O		30.6	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g.	Other Industries	Liquid Fuels	N_2O	9.9	1.2	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g.	Other Industries	Solid Fuels	N_2O	28.2	16.7	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g.	Other Industries	Gaseous Fuels	N_2O	0.3	2.4	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g.	Other Industries	Biomass	N_2O		17.8	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.a.	Domestic Aviation	Jet kerosene	N_2O	7.9	30.5	5.5	85.0	85.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b.	Road Transportation	Gasoline	N_2O	256.3	294.8	10.0	250.0	250.2	0.0	0.0	0.0	0.8	0.0	0.6
1.A.3.b.	Road Transportation	Diesel oil	N_2O	221.9	938.8	10.0	250.0	250.2	0.2	0.0	0.0	0.4	0.1	0.2
1.A.3.b.	Road Transportation	Liquefied petroleum gases (LPG)	N_2O		7.8	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b.	Road Transportation	Gaseous fuels	N_2O		2.4	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b.	Road Transportation	Biomass	N_2O		6.9	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.c.	Railways	Liquid fuels	N_2O	60.8	47.9	5.0	142.0	142.1	0.0	0.0	0.0	0.1	0.0	0.0
1.A.3.c.	Railways	Solid fuels	N_2O	0.3		5.0	150.0	150.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.d.	Domestic Navigation	Residual fuel oil	N_2O	1.9	0.4	15.0	140.0	140.8	0.0	0.0	0.0	0.0	0.0	0.0

Table A8 Approach 1 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 Gg CO_2 eq	Emissions in 2022 Gg CO_2 eq	AD Unc. %	EF Unc. %	Combined Unc. %	H(1) %	I(2) %	J(3) %	K(4) %	L(5) %	M(6) %
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N_2O	1.6	7.9	15.0	140.0	140.8	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.e.	Pipeline Transportation	Gaseous fuels	N_2O	0.0	0.2	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a.	Commercial/institutional	Liquid fuels	N_2O	4.0	0.8	7.1	100.0	100.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a.	Commercial/institutional	Solid fuels	N_2O	2.0	10.5	14.1	100.0	101.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a.	Commercial/institutional	Gaseous fuels	N_2O	0.0	5.4	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.b.	Residential	Liquid fuels	N_2O	6.5	0.4	7.1	100.0	100.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.b.	Residential	Solid fuels	N_2O	52.2	47.8	14.1	100.0	101.0	0.0	0.0	0.0	0.1	0.0	0.0
1.A.4.b.	Residential	Gaseous fuels	N_2O	0.0	16.5	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.b.	Residential	Biomass	N_2O	319.9	72.9	300.0	100.0	316.2	0.0	0.0	0.0	0.6	0.2	0.4
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	N_2O	605.0	1 010.0	14.1	250.0	250.4	0.3	0.0	0.0	1.3	0.1	1.8
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	N_2O		0.1	7.0	100.0	100.2	0.0	0.0	0.0	0.0	0.0	0.0
1.B.2.c.	Venting and flaring		N_2O	0.8	0.8	7.0	100.0	100.2	0.0	0.0	0.0	0.0	0.0	0.0
2.B.2.	Nitric acid production		N_2O	945.8	1 580.4	2.0	20.0	20.1	0.0	0.0	0.0	0.2	0.0	0.0
3.B.	Manure management		N_2O	2 742.7	4 366.4	14.1	50.0	52.0	0.2	0.0	0.0	1.3	0.5	1.9
3.D.a	Direct N2O emissions from agricultural soils		N_2O	13 490.4	19 790.3	18.9	104.0	105.7	17.3	0.1	0.1	14.2	3.3	213.3
3.D.b	Indirect N2O emissions from agricultural soils		N_2O	1 900.7	2 527.5	93.4	109.5	143.9	0.5	0.0	0.0	2.3	2.1	9.5
3.F.	Field burning of agricultural residues		N_2O	72.9	36.0	50.0	40.0	64.0	0.0	0.0	0.0	0.0	0.0	0.0
4.A.	Forest land		N_2O	48.4	38.0	23.5	0.9	23.5	0.0	0.0	0.0	0.0	0.0	0.0
4.B.	Cropland		N_2O		24.6	23.5	4.5	23.9	0.0	0.0	0.0	0.0	0.0	0.0
4.C.	Grassland		N_2O		2.9	23.5	4.5	23.9	0.0	0.0	0.0	0.0	0.0	0.0
4.D.	Wetlands		N_2O		3.9	23.5	4.5	23.9	0.0	0.0	0.0	0.0	0.0	0.0
5.B.	Biological treatment of solid waste		N_2O	4.6	7.4	10.0	20.0	22.4	0.0	0.0	0.0	0.0	0.0	0.0
5.C.	Incineration and open burning of waste		N_2O	9.8	0.8	30.4	100	104.5	0.0	0.0	0.0	0.0	0.0	0.0
5.D.1	Wastewater treatment and discharge		N_2O	1 281.4	2 131.9	30	42.4	51.9	0.0	0.0	0.0	0.5	0.6	0.5
	Total N_2O		**CO_2 eq**	**22 227.9**	**34 355.3**									

Table A8 Approach 1 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 Gg CO_2 eq	Emissions in 2022 Gg CO_2 eq	AD Unc. %	EF Unc. %	Combined Unc. %	H[(1)] %	I[(2)] %	J[(3)] %	K[(4)] %	L[(5)] %	M[(6)] %
2.E.5.	Other		HFC		0.1	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
2.F.3.	Fire protection		HFC		401.8	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.1	0.0
2.F.6.	Other applications		HFC		9782.2	25.0	5.0	25.5	0.2	0.1	0.1	0.3	2.1	4.7
2.C.3.	Aluminium Production		PFC	424.7	7.7	2.0	5.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0
2.E.5.	Other		PFC		0.0	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
2.C.4.	Magnesium Production		SF6		44.0	5.0	5.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0
2.E.5.	Other		SF6		70.8	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
2.G.1.	Electrical equipment		SF6		93.6	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
	Total HFCs, PFCs and SF_6		**CO_2 eq**	**424.7**	**10 400.1**									
Total all gases with LULUCF				**161 572.2**	**502 175.0**		**Overall Unc.**	**8.9**		**Trend Unc.**		**36.4**		
Total all gases without LULUCF				**228 001.9**	**558 270.5**		**Overall Unc.**	**5.2**		**Trend Unc.**		**10.9**		

(1) Contribution to Variance by Category in Year t
(2) Type A sensitivity
(3) Type B sensitivity
(4) Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty
(5) Uncertainty in trend in national emissions introduced by activity data uncertainty
(6) Uncertainty introduced into the trend in total national emissions

Annex 3: Reference Approach & National Energy Balance 2022 (thousand toe)

Distribution of Energy Supply	Hard Coal	Lignite	Asphaltite	Coke	Derivative Gases	BFG	COG	BOF Gas	Coal Tar	Oil	Oil Products	Petroleum Coke	Fuel Oil
Domestic Production (+)	822	18.145	666		0					3.762	0		
Import (+)	22.659			791	0				0	35.161	28.603	2.228	2.222
Export (-)	400	3		63	0				93		9.527	89	1.576
Bunkers (-)					0						5.796	0	227
Stock Change (+/-)	-189	-499	-22		0				-22	-224	75	-102	-425
Primary Energy Supply	**23.083**	**17.673**	**644**	**728**	**0**	**0**	**0**	**0**	**-109**	**38.699**	**6.414**	**2.029**	**-6**
Statistical Difference (+/-)	**186**	**287**	**0**	**264**	**0**	**0**	**0**	**0**	**7**	**0**	**-570**	**81**	**-318**
Transformation Sector	**-17.679**	**-12.798**	**-342**	**2.590**	**640**	**78**	**338**	**32**	**119**	**-38.699**	**36.911**	**1.091**	**-186**
Electricity and Heat Production[1]	-13.167	-12.467	-342	0	-643	**-401**	-177	**-65**	0	0	-908	**-258**	**-145**
Main activity producer plants	-12.126	-12.373	-342		0						-610	-81	-25
Autoproducers	-1.040	-95	0		-643	-401	-177	-65			-298	-178	-119
Heat Production	-382	-296			-160	-92	-27	-42			-80		-80
Coke ovens	-4.017			2.590	815		815		119		0		
Blast Furnaces					1.326	1.156		169			0		
Petroleum Refineries					0					-38.337	42.673	1.370	1.945
Own use and losses	-113	-35	0		-698	-594	-273	-30		-362	-4.768		-1.803
Total final energy consumption	**5.404**	**4.875**	**303**	**3.318**	**640**	**78**	**338**	**32**	**10**	**0**	**43.326**	**3.120**	**-193**
Sectors Total	**5.218**	**4.588**	**303**	**3.014**	**640**	**78**	**330**	**32**	**3**	**0**	**43.895**	**3.039**	**125**
Industry Consumption	**3.519**	**2.913**	**171**	**3.014**	**640**	**78**	**338**	**32**	**3**	**0**	**3.540**	**3.039**	**39**
Mining and Quarrying (07,08,09)	**0**	**13**		**0**	**0**						**111**	**13**	**3**
Manufacture of Food, beverage, tobacco products (10,11,12)	**254**	**672**	**0**	**31**	**0**	**0**	**0**	**0**	**0**	**0**	**28**	**1**	**5**
Food (10)	254	666		0	0						24	1	3
Beverages (11)	0	0		0	0						1	0	0
Tobacco (12)	0	0		0	0						0	0	0
Sugar (10.81)	0	0		31	0						2	0	2
Manufacture of textile and leather (13,14,15)	**237**	**535**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**40**	**0**	**13**
Textile (13)	227	506		0	0						37	0	13
Clothing (14)	10	30		0	0						2	0	0
Leather and related (15)	1	0		0	0						1	0	0
Manufacture of wood products (16)	**17**	**5**		**0**	**0**						**10**	**0**	**0**
Manufacture of paper (17,18)	**59**	**174**		**0**	**0**						**6**	**3**	**1**
Manufacture of chemicals and petro chemicals (20,21,22)	**344**	**215**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**18**	**0**	**3**
Chemicals (20)	341	160		0	0						14	0	2
Fertilizer (20)	0	0		0	0						2	0	1
Pharmaceutical (21)	2	0		0	0						0	0	0
Rubber plastics (22)	0	55		0	0						3	0	0
Manufacture of non metallic minerals (23)	**1.782**	**1.267**	**0**	**0**	**2**	**0**	**2**	**0**	**0**	**0**	**3.161**	**3.022**	**14**
Glass (23)	0	0		0	0						25	0	4
Ceramics (23)	3	240		0	0						39	31	1
Cement (23)	1.689	1.027		0	2		2				3.100	2.991	8
Basic Metal Industry (24,25)	**985**	**25**	**0**	**2.974**	**638**	**78**	**336**	**32**	**3**	**0**	**31**	**0**	**0**
Iron and steel (24)	881	8		2.968	638	78	336	32	3		23	0	0
Non-ferrous metals (24)	41	17		0	0						5	0	0
Fabricated metal products (25)	0	0		0	0						2	0	0
Manufacture of machine, electrical and electronical products (	**0**	**2**		**0**	**0**						**4**	**0**	**0**
Manufacture of transportation Equipment(29,30)	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**17**	**0**	**0**
Motorized land vehicles (29)	0	0		0	0						14	0	0
Other transportation vehicles (30)	0	5		0	0						3	0	0
Furniture and other production(31)	**0**	**0**		**0**	**0**						**1**	**0**	**0**
Construction(41,42,43)	**1**	**0**		**0**	**0**						**13**	**0**	**0**
Other industry	**0**	**0**	**171**	**0**	**0**						**102**	**0**	**0**
TRANSPORT	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**38.168**	**0**	**19**
Rail					0						151		0
Domestic Navigation					0						374		19
Domestic Aviation					0						1.128		0
Pipelines					0						0		0
Road					0						28.517		0
Other Sectors	**1.699**	**1.675**	**131**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3.942**	**0**	**67**
Residential	1.416	1.247	131		0						382		
Commercial and Public services	283	428	0		0						379		67
Agriculture and fishing	0	0	0		0						3.183		
Non Energy Use	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6.245**	**0**	**0**
Petrochemicals Feedstock					**0**						**1.780**		

Distribution of Energy Supply	Gas Diesel Oil	Gasoline	LPG	Refinery Gas	Jet Kerosene	Kerosene	Naphta	By Products	Base oil	White Spirit	Bitumen	Others
Domestic Production (+)												
Import (+)	11.147	0	3.622		478		302	164	396	32	2	77
Export (-)	2.487	2.108	463		274		717	509	280	0	980	44
Bunkers (-)	434	0			4.134							
Stock Change (+/-)	517	-24	-34	1	33	0	-38	-3	34	4	-23	135
Primary Energy Supply	**8.743**	**-2.132**	**3.125**	**1**	**-3.897**	**0**	**-453**	**-349**	**150**	**36**	**-1.002**	**168**
Statistical Difference (+/-)--	**0**	**0**	**-146**	**0**	**0**	**0**	**-187**	**0**	**0**	**0**	**0**	**0**
Transformation Sector	**16.916**	**5.455**	**1.106**	**-1**	**5.023**	**2**	**2.046**	**647**	**86**	**4**	**2.367**	**2.356**
Electricity and Heat Production[4]	**-504**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Main activity producer plants	-504		0									
Autoproducers			0									
Heat Production			0									
Coke ovens												
Blast Furnaces												
Petroleum Refineries	18.303	5.529	1.243	1.766	5.023	2	2.046	653	86	4	2.367	2.356
Own use and loses	-883	-74	-137	-1.767				-6				
Total final energy consumption	**25.659**	**3.322**	**4.231**	**0**	**1.126**	**2**	**1.593**	**299**	**236**	**41**	**1.365**	**2.524**
Sectors Total	**25.659**	**3.322**	**4.377**	**0**	**1.126**	**2**	**1.780**	**299**	**236**	**41**	**1.365**	**2.524**
Industry Consumption	**276**	**1**	**185**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Mining and Quarrying (07,08,09)	**95**	**0**	**0**									
Manufacture of Food, beverage, tobacco products 10,11,12)	**10**	**0**	**12**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Food(10)	10	0	11									
Beverages(11)	0	0	1									
Tobacco (12)	0	0	0									
Sugar(10.81)	0	0	0									
Manufacture of textile and leather (13,14,15)	**4**	**0**	**23**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Textile13)	2	0	22									
Clothing (14)	2	0	0									
Leather and related (15)	1	0	0									
Manufacture of wood products (16)	**9**	**0**	**0**									
Manufacture of paper (17,18)	**2**	**0**	**0**									
Manufacture of chemicals and petro chemicals (20,21,22)	**7**	**0**	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Chemicals(20)	4	0	8									
Fertilizer (20)	1	0	0									
Pharmaceutical (21)	0	0	0									
Rubberi plastics (22)	2	0	1									
Manufacture of non-metalic minerals (23)	**107**	**0**	**18**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Glass (23)	7	0	12									
Ceramics (23)	7	0	0									
Cement (23)	94	0	6									
Basic Metal Industry (24,25)	**21**	**0**	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Iron and steel (24)	14	0	9									
Non-ferrous metals (24)	5	0	0									
Fabricated metal products 25)	2	0	0									
Manufacture of machine, electrical and electronical products (2	**2**	**0**	**2**									
Manufacture of transportation Equipment(29,30)	**5**	**0**	**12**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Motorized land vehicles 29)	3	0	11									
Other transportation vehicles (30)	2	0	0									
Furniture and other production(31)	**0**	**0**	**0**									
Construction(41,42,43)	**13**	**0**	**0**									
Otherr industry	**0**	**0**	**101**									
TRANSPORT	**22.201**	**3.321**	**3.501**	**0**	**1.126**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Rail	151											
Domestic Navigation	355											
Domestic Aviation					1.126							
Pipelines												
Road	21.695	3.321	3.501									
Other Sectors	**3.183**	**0**	**691**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**
Residential			380			2						
Commercial and Public services			311									
Agriculture and farming	3.183											
Non Energy Use	**0**	**0**	**0**	**0**	**0**	**0**	**1.780**	**299**	**236**	**41**	**1.365**	**2.524**
Petrochemicals Feedstock							**1.780**					

Distribution of Energy Supply	Nat. Gas	Biofuels and Waste	Wood	Crop and animal residue	Biofuels	Hydro	Wind	Electricty	Other Heat	Jeothermal	Solar	Total
Domestic Production (+)	337	4.513	1.360	2.993	160	5.745	3.005		0	11.514	2.321	50.830
Import (+)	45.096	0						554	0			125.129
Export (-)	480	0						319	0			10.893
Bunkers (-)		0							0			4.796
Stock Change (+/-)	-1.649	0							0			-2.500
Primary Energy Supply	43.304	4.513	1.360	2.993	160	5.745	3.005	234	0	11.514	2.321	157.770
Statistical Difference (+/-)--	0	0	0	0	0	0	0	0	0	0	0	215
Transformation Sector	-13.435	-1.582	0	-1.582	0	-5.745	-3.005	24.184	2.703	-9.560	-1.452	-37.350
Electricity and Heat Production[4]	-11.678	-1.581	0	-1.581	0	-5.745	-3.005	28.241	939	-9.560	-1.452	-31.368
Main activity producer plants	-9.622	-1.563		-1.563		-5.741	-2.992	26.040	432	-9.560	-1.014	-29.472
Autoproducers	-2.056	-18		-18		-4	-13	2.201	507		-438	-1.897
Heat Production	-1.266	-1		-1				0	2.116			5
Coke ovens		0							0			-494
Blast Furnaces		0							0			1.326
Petroleum Refineries	-435	0						-227	-352			3.322
Own use and loses	-56	0						-3.829	0			-10.141
Total final energy consumption	29.869	2.931	1.360	1.412	160	0	0	24.419	2.703	1.954	869	120.420
Sectors Total	29.869	2.931	1.360	1.412	160	0	0	24.419	2.703	1.954	869	120.205
Industry Consumption	9.045	1.129	0	1.129	0	0	0	11.594	2.654	0	85	38.107
Mining and Quarrying (07,08,09)	132	0		0				222	200			677
Manufacture of Food, beverage, tobacco products 10,11,12)	987	25	0	25	0	0	0	852	502	0	0	3.350
Food(10)	922	25		25				720	502			3.113
Beverages(11)	27	0		0				50	0			79
Tobacco (12)	14	0		0				18	0			32
Sugar(10.81)	25	0		0				63	0			126
Manufacture of textile and leather (13,14,15)	1.042	13	0	13	0	0	0	1.743	65	0	0	3.685
Textile13)	909	12		12				1.452	65			3.216
Clothing (14)	121	0		0				251	0			415
Leather and related (15)	13	0		0				40	0			54
Manufacture of wood products (16)	39	381		381				238	75			764
Manufacture of paper (17,18)	145	9		9				366	324			1.082
Manufacture of chemicals and petro chemicals (20,21,22)	2.351	3	0	3	0	0	0	1.446	172	0	0	4.549
Chemicals(20)	1.568	2		2				676	156			2.917
Fertilizer (20)	565	0		0				57	0			624
Pharmaceutical (21)	60	0		0				55	0			117
Rubberi plastics (22)	158	2		2				659	16			892
Manufacture of non-metalic minerals (23)	1.738	688	0	688	0	0	0	1.254	57	0	0	9.870
Glass (23)	701	0		0				175	0			898
Ceramics (23)	850	0		0				235	0			1.367
Cement (23)	188	688		688				844	57			7.604
Basic Metal Industry (24,25)	1.886	4	0	4	0	0	0	3.136	330	0	0	9.732
Iron and steel (24)	1.457	2		2				2.475	269			8.495
Non-ferrous metals (24)	248	0		0				456	61			837
Fabricated metal products 25)	181	2		2				205	0			400
Manufacture of machine, electrical and electronical products (2	139	2		2				267	3			417
Manufacture of transportation Equipment(29,30)	214	0	0	0	0	0	0	268	6	0	0	511
Motorized land vehicles 29)	198	0		0				215	6			434
Other transportation vehicles (30)	16	0		0				53	0			77
Furniture and other production(31)	36	3		3				67	0			107
Construction(41,42,43)	276	0		0				342	0			632
Otherr industry	60	0		0				1.393	921		85	2.731
TRANSPORT	258	160	0	0	160	0	0	135	0	0	0	30.721
Rail		0						111				262
Domestic Navigation		0										374
Domestic Aviation		0										1.126
Pipelines	187	0						23				211
Road	71	160			160							28.748
Other Sectors	19.791	1.643	1.360	283	0	0	0	12.690	49	1.954	784	44.358
Residential	14.856	1.643	1.360	283				5.283	0	853	784	26.674
Commercial and Public services	4.842	0						6.224	49	475		12.598
Agriculture and farming	93	0						1.183	0	627		5.085
Non Energy Use	775	0	0	0	0	0	0	0	0	0	0	7.020
Petrochemicals Feedstock												1.780

Energy balance sheets for 1972-2022 are available on the MENR website (https://www.eigm.gov.tr/tr-TR/Denge-Tablolari/Denge-Tablolari).

Annex 4: Country Specific Carbon Content Determination and Emission Factors

In Türkiye we do not have ETS registry yet. Therefore, in order to calculate country specific EFs, we lean on data obtained from a number of coal firing plants, BOTAŞ and some public university laboratories. Those analyses are the basis of country specific Carbon Contents.

Natural gas

In order for carbon content of natural gas to be calculated, densities of gases included in it must be known to convert volumetric compositions to mass fractions.
Volumetric fractions of gas concentrations were obtained through gas chromatography analysis from Petroleum Pipeline Corporation (BOTAŞ). Using density of the gases and some stoichiometry carbon mass amount coming from each gas was calculated and summed up to reach an overall carbon amount. For gaseous fuels CO measured in the stack gas was used in order to calculate unoxidised carbon's mass percentage and then oxidation rate of the related fuel. In order to calculate the oxidation rate of gaseous fuels (natural gas), CO concentration measured in the stack gas of the related plants were obtained from the Ministry of Environment, Urbanization and Climate Change.

Turkish Lignite

Ultimate analysis results, which were obtained from coal firing plants, were used to calculate carbon content of the related coal types. In the analysis results Carbon content together with, Hydrogen, Sulphur, Oxygen moisture, ash, volatile substances contents are measured. Also net and gross calorific values are provided in the same reports. Carbon contents and net calorific values (circulated figures in the below analysis report) are used for calculating carbon content of Turkish lignite.

Oxidation rate of solid fuels was calculated by using the mass percentage of carbon in ash-slag analysis reports which were obtained from coal firing plants.

Hard coal

Carbon contents and oxidation rates of hard coal is calculated in the same way as in Turkish Lignite.
Country specific carbon content and oxidation rates of hard coal calculated based on power plants coal analysis are used for all 1.A categories.

Coke oven coke

Country specific Carbon content of coke oven coke is calculated based on carbon content and net calorific values provided by the integrated iron&steel facilities in Türkiye. There are 3 integrated iron&steel facilities in Türkiye and there are coke production plants in all of them. Carbon contents of all carbonaceous material used for iron and steel production is measured by all the facilities. Carbon content of coke oven coke is also measured since it is used as reducing agent in pig iron production. Annual average carbon content of coke oven coke as kg C/ton of coke and net calorific values are compiled from integrated facilities. The mass of carbon is divided by net calorific values of coke oven coke and the result is the carbon content as kg C/GJ of coke. Calculated country specific carbon content is used for estimation of CO_2 emissions from coke combustion of all other sectors using coke as a fuel.

Gas/diesel oil and Residual fuel oil

Carbon content of gas/diesel oil and residual fuel oil is calculated based on fuel analysis made by Petroleum Research Centre at Middle East Technical University (METU) in Ankara. The Research Center was founded by METU Petroleum Engineering Department and General Directorate of Petroleum Affairs (under the Ministry of Energy and Natural Resources). The main objective of the Center is to make research on the oil and gas exploration and production, refining and transportation and to conduct projects on topics requested by public and private organizations.

Based on the fuel analysis of Petroleum Research Center, an example for calculation of carbon content of gas diesel oil and residual fuel oil is given below.

Sample A	Number of Sample B	C, normalized (%) C	NCV kcal/kg (average) D	NCV GJ/kg (average) E	C mass/kg fuel F (C/100)	C content kg C/GJ G (F/E)
Diesel	639/06-1106	86.261	10233	0.0428435	0.86261	20.133975
Fuel Oil	255/06-330	86.611	9901	0,0414535	0.86611	20.893530

Source: METU, Petroleum Research Laboratory, 2006.

An example for oxidation rate for gas diesel oil and residual fuel oil;

Oxidation rate of gas/diesel oil and residual fuel oil is calculated based on stack gas analysis of oil fired power plants. In stack gas analysis, CO percentage in stack gas is measured. Based on the inlet carbon already provided in fuel analysis report and outlet C derived from stack gas analysis, oxidation rates are calculated.

An example calculation is given below.

		Fuel oil density (kg/m3)	0.9757
CO (average v/v %)	3.25	**C inlet (m/m) %**	86.611
C (outlet v/v %) (*12/28)	1.39	**C inlet (v/v) %**	88.768

Oxidation rate, %: ((C inlet - C outlet)/C inlet)*100 = 98.43

Petroleum coke

Petroleum coke is used in mostly in cement factories. There are around 54 cement factories in Türkiye. Availability of fuel analysis report is asked to the factories via official letters. Net calorific values are available in most of the factories but a few of them has carbon content analysis. Averages of all available data are used as country specific carbon content of petroleum coke.

Emissions Factors

Emission Factors used in the Energy Sector

NCV of Fuels

	2022	Unit
Hard coal	25.40	TJ/kton
Lignite	8.24	TJ/kton
Asphaltite	17.40	TJ/kton
Coke	30.77	TJ/kton
BFG	731	Kcal/kg
Coke oven gas	3 850	Kcal/kg
BOF gas	1 547	Kcal/kg
Oil	43.96	TJ/kton
Coal tar	37.25	TJ/kton
Petroleum Coke	32.24	TJ/kton
Fuel oil	39.39	TJ/kton
Diesel oil	43.33	TJ/kton
Gasoline	44.80	TJ/kton
LPG	47.31	TJ/kton
Refinery gas	48.15	TJ/kton
Jet Kerosene	44.59	TJ/kton
Kerosene	43.75	TJ/kton
Naphtha	45.01	TJ/kton
By products	40.19	TJ/kton
Basic oil	42.00	TJ/kton
White spirit	43.50	TJ/kton
Bitumen	40.19	TJ/kton
Other petroleum products	40.19	TJ/kton
Natural gas	34.54	TJ/10^6m3
Wood	12.04	TJ/kton
Crop and animal residue	11.14	TJ/kton
Biofuels	36.05	TJ/kton

(TJ/kt) = (1000 TOE)/(kt) * 41.868

(TJ/10^6m3) = (1000 TOE)/(10^6m3) * 41.868

Country Specific CO_2 Emission Factors							(t/TJ)
Years	**Hard Coal**	**Lignite**	**Coke**	**BFG**	**COG**	**BOF Gas**	**Natural Gas**
1990	93.37	114.16	110.29	258.85	40.46	176.53	55.61
1991	101.38	114.01	110.29	258.85	40.46	176.53	55.61
1992	101.35	113.85	110.29	258.85	40.46	176.53	55.61
1993	100.54	113.70	110.29	258.85	40.46	176.53	55.61
1994	99.12	113.54	110.29	258.85	40.46	176.53	55.61
1995	102.17	113.39	110.29	258.85	40.46	176.53	55.61
1996	102.50	113.23	110.29	258.85	40.46	176.53	55.61
1997	103.34	113.08	110.29	258.85	40.46	176.53	55.61
1998	102.81	112.92	110.29	255.17	40.25	176.53	55.61
1999	93.39	112.77	110.29	255.17	40.27	176.53	55.61
2000	95.52	110.05	110.29	260.85	40.27	176.53	55.61
2001	99.28	110.58	110.29	261.55	40.90	176.53	55.61
2002	96.27	111.30	110.29	261.55	40.60	176.53	55.61
2003	100.90	112.00	110.70	261.55	41.51	176.53	55.65
2004	90.34	112.72	110.62	261.55	41.76	176.53	55.61
2005	94.23	113.50	112.25	256.64	43.40	176.53	55.60
2006	88.71	114.18	110.29	261.55	40.88	176.53	55.61
2007	88.52	113.62	111.97	264.06	41.41	176.53	55.62
2008	93.35	112.51	110.29	257.53	40.91	176.53	55.62
2009	96.03	111.39	111.58	259.33	41.85	175.60	55.68
2010	98.56	110.26	109.79	257.31	41.22	179.97	55.74
2011	95.10	109.48	110.05	257.81	39.36	174.71	56.31
2012	96.65	109.29	111.01	256.94	40.05	174.81	55.66
2013	96.18	109.09	112.45	252.27	42.12	176.39	55.66
2014	93.15	107.63	110.71	251.92	42.03	173.73	55.68
2015	92.38	107.63	110.38	258.70	40.78	175.09	55.75
2016	85.32	107.41	108.37	265.09	39.02	182.31	55.39
2017	94.50	107.24	112.22	264.12	37.45	190.08	55.62
2018	93.25	108.88	108.08	268.30	37.35	194.38	55.27
2019	96.89	106.62	108.48	285.82	38.87	194.80	53.67
2020	91.76	104.75	110.70	260.32	39.74	196.53	55.67
2021	93.64	104.08	108.77	255.95	42.30	195.64	55.43
2022	91.71	104.68	112.90	271.18	40.20	213.04	55.72

Default CO_2 Emission Factors

Fuels	1990-2022
Sub bituminous coal	96.1
Coal tar	80.7
Crude oil	73.3
Petroleum Coke	97.4
Fuel Oil	77.0
Diesel Oil	72.3
Gasoline	69.3
LPG	63.1
Refinery gas	57.6
Jet kerosene	71.5
Kerosene	71.9
Naphtha	72.7
By products	73.3
Basic oil	73.3
White spirit	73.3
Bitumen	80.7
Other petroleum products	73.3
Navigation diesel oil	72.3
Navigation fuel	77.0
Wood	111.8
Biofuels and Waste	100.1

CH_4 and N_2O Emission Factors

	EF		Source
Sub-sectors	**CH_4**	**N_2O**	
	(kg/TJ)	**(kg/TJ)**	
1A1b sector			
Fuel oil	3	0.6	Table 2.3 page 2.18
Diesel oil	3	0.6	Table 2.3 page 2.18
Natural gas	1	0.1	Table 2.3 page 2.18
Refinery gas	1	0.1	Table 2.3 page 2.18
FCC coke	3	0.6	Table 2.3 page 2.18
1A1c sector			
Derived gases	1	0.1	Table 2.3 page 2.18
1A2 sector			
Coal products	10	1.5	Table 2.3 page 2.18
LPG	1	0.1	Table 2.3 page 2.18
Other petroleum products	3	0.6	Table 2.3 page 2.18
Derived gases	1	0.1	Table 2.3 page 2.18
Wood	30	4.0	Table 2.3 page 2.18
Natural gas	1	0.1	Table 2.3 page 2.18
1A4a sector			
Coal products	10	1.5	Table 2.4 page 2.20
LPG	5	0.1	Table 2.4 page 2.20
Other petroleum products	10	0.6	Table 2.4 page 2.20
Wood	300	4.0	Table 2.4 page 2.20
Natural gas	5	0.1	Table 2.4 page 2.20
Sectors 1A4b and 1A4c			
Coal products	300	1.5	Table 2.5 page 2.22
LPG	5	0.1	Table 2.5 page 2.22
Other petroleum products	10	0.6	Table 2.5 page 2.22
Wood	300	4.0	Table 2.5 page 2.22
Other primary solid biomass	300	4.0	Table 2.5 page 2.22
Natural gas	5	0.1	Table 2.5 page 2.22

All table references given above refer to the 2006 IPCC Guidelines Volume 2.

Emission factors used in the IPPU sector

Category		EF	Reference
Cement Production	CKD	1.02	D
	EF	0.5160	CS
Lime Production	EF high calcium lime (tonnes CO_2/tonne carbonate)	0.6930	CS
	EF dolomitic lime (tonnes CO_2/tonne carbonate)	0.77	D, Table 2.4., Volume 3
Glass production/Ceramics /Roof and Tiles/ Soda ash use	Soda (tonnes CO_2/tonne carbonate)	0.41492	D, Table 2.1., Volume 3
	Dolomit (tonnes CO_2/tonne carbonate)	0.47732	D, Table 2.1., Volume 3
	Kalker (tonnes CO_2/tonne carbonate)	0.43971	D, Table 2.1., Volume 3
Magnesia Production	Magnesia (tonnes CO_2/tonne carbonate)	0.52197	D, Table 2.1., Volume 3
Ammonia Production	Natural Gas NCV (kcal/sm3)	8421.7	BOTAŞ
	Natural Gas NCV (GJ/sm3)	0.03526	BOTAŞ
	Nat Gas. Car. Cont. (kgC/GJ)	15.2	BOTAŞ
	Carbon Oxidation Factor	1	D, Ch 2, Volume 2
Nitric Acid Production	Middle pressure plant (kg N_2O/tonne nitric acid)	7	D, Table 3.3., Volume 3
	with abatement technology (kg N_2O/tonne nitric acid)	2.5	D, Table 3.3., Volume 3
Carpide Production	Carpide (tonnes CO_2/tonne carbide produced)	1.09	D, Table 3.8., Volume 3
	Asetilen (tonnes CO_2/tonne carbide produced)	1.1	D, Table 3.8., Volume 3
Soda Ash Production	Soda ash (tonnes CO_2/tonne of Trona)	0.097	D, Equation 3.14., Volume 3
Petrochemicals	Fuel gas	0.67227	CS, PETKIM
Iron and Steel Production	EAF	0.0712	CS
	Integrated Plants	C	PS, Confidential
Ferro chrome production	Ferrochromium (tonnes CO_2/tonne product)	1.3	D, Table 4.5, Volume 3
Aluminium production	Net prebaked anode consumption (tonnes CO_2/tonne aluminium)	C	PS, Confidential
	Carbon content wt %	C	PS, Confidential
Magnesium production	Dolomite (tonnes CO_2 emissions/tonne primary Mg Produced)	5.13	D, Table 4.19, Volume 3
Lead production	Default EF (tonnes CO_2 / tonne product)	0.2	D, Table 4.21, Volume 3
Zinc production	Waelz Kiln (tonnes CO_2 / tonne product)	3.66	D, Table 4.24, Volume 3
Lubricant and paraffin wax use	Carbon content	20	D, Table 5.2, Volume 3
	ODU factor	0.2	D, Ch 5, Volume 3

All table references given above refer to the 2006 IPCC Guidelines.

Emission factors/parameters used in the agriculture sector

3.A Enteric Fermentation	EF (kg CH_4/head/yr)	Method	Note
3.A.1 Cattle			
Dairy Cattle	85.8	T2	Latest Inventory year figure
Non-Dairy Cattle	49.8	T2	Latest Inventory year figure
3.A.2 Sheep			
Domestic	5.0	T1	Table 10.10
Merino	5.73	T1	Approximate emission factor
3.A.3 Swine	1.0	T1	Table 10.10
3.A.4 Other livestock			
Buffalo	55.0	T1	Table 10.10
Camels	46.0	T1	Table 10.10
Goats	5.0	T1	Table 10.10
Horses	18.0	T1	Table 10.10
Mules and Asses	10.0	T1	Table 10.10
Poultry	NA		

All table references given above refer to the 2006 IPCC Guidelines Volume 4 except for EFs given for cattle.

3.B(a) Manure Management CH_4 Emissions	EF (kg CH_4/head/yr)	Method	Note
3.B.1 Cattle			
Dairy Cattle	a	T1	Table 5.17
Non-Dairy Cattle	a	T1	Table 5.17
3.B.2 Sheep			
Domestic	b	T1	Table 5.18
Merino	b	T1	Table 5.18
3.B.3 Swine	a	T1	Table 5.17
3.B.4 Other livestock			
Buffalo	b	T1	Table 5.18
Camels	b	T1	Table 5.18
Goats	b	T1	Table 5.18
Horses	b	T1	Table 5.18
Mules and Asses	b	T1	Table 5.18
Poultry	b	T1	Table 5.18

[a] Table 5.17 of this National Inventory Document.

[b] Table 5.18 of this National Inventory Document.

Emission factors/parameters used in the agriculture sector (continued)

3.B(b) Manure Management Direct N_2O Emissions	**EF_3 (kg N_2O-N / kg N excreted)**	**Method**	**Note**
Liquid system	0.005	T1	Table 10.21
Solid storage	0.005	T1	Table 10.21
Dry lot	0.02	T1	Table 10.21
Pasture, range and paddock	-	T1	Reported under 3.D agricultural soils category
Burned for fuel or as waste	-	T1	Reported under the energy sector
Other (Poultry manure)	0.001	T1	Table 10.21

All table references given above refer to the 2006 IPCC Guidelines Volume 4.

3.B(b) Manure Management Indirect N_2O Emissions	**Value**	**Method**	**Note**
All related manure management systems	0.01	T1	Table 11.3, EF_4 [kg N2O-N / (kg NH3-N + NOx-N volatilised)]
$Frac_{GASMS}$	***	T1	***Default values given on Table 10.22
$Frac_{LEACHMS}$	4.5%	T1	Mid-value between 3% and 6% given for drier climates on page 10.56

All value, table and page references given above refer to the 2006 IPCC Guidelines Volume 4.

3.C Rice Cultivation	**Value**	**Unit**	**Method**	**Note**
EF_c	1.30	kg CH4 /ha/ day	T1	Baseline emission factor for all types of water regimes, Table 5.11
SF_w	1.00		T1	Scaling factor for continuously flooded water regime, Table 5.12
SF_w	0.60		T1	Scaling factor for intermittently flooded (single aeration) water regime, Table 5.12
SF_w	0.52		T1	Scaling factor for intermittently flooded (multiple aeration) water regime, Table 5.12
SF_p	1.00		T1	Scaling factor for non-flooded pre-season less than 180 days, Table 5.13
SF_p	0.68		T1	Scaling factor for non-flooded pre-season more than 180 days, Table 5.13
SF_p	1.90		T1	Scaling factor for flooded pre-season over 30 days, Table 5.13

All table references given above refer to the 2006 IPCC Guidelines Volume 4.

Emission factors/parameters used in the agriculture sector (continued)

3.D.1 Agricultural Soils Direct N_2O Emissions		EF	Unit	Note
3.D.1.a	Inorganic N fertilizers	0.01	kg N_2O–N / (kg N)	-
3.D.1.b	Organic N fertilizers	0.01	kg N_2O–N / (kg N)	-
3.D.1.c	Urine and dung deposited by grazing animals	**	kg N_2O–N / (kg N)	**0.02 for cattle, buffalo, pigs, poultry and 0.01 for sheep and other animals
3.D.1.d	Crop residues	0.01	kg N_2O–N / (kg N)	0.003 is taken for flooded rice & 0.01 for crop residues except flooded rice
3.D.1.e	Mineralization/Immobilization associated with loss/gain of soil organic matter	0.01	kg N_2O–N / (kg N)	-
3.D.1.f	Cultivation of organic soils	8	kg N_2O–N / ha	$EF_{2\ CG,\ Temp}$ for temperate organic crop and grassland soils

All EF values given above refer to Table 11.1 of the 2006 IPCC Guidelines Volume 4. The method used for 3.D.a is T1.

3.D.2 Agricultural Soils Indirect N_2O Emissions	Value	Unit	Note
EF_4	0.01	kg N2O-N / (kg NH3-N + NOx-N volatilised)	N volatilisation and re-deposition
EF_5	0.0075	kg N2O-N / (kg N leaching/runoff)	Leaching/runoff
$Frac_{GASF}$	0.10	kg NH3-N + NOx-N / (kg N applied)	Volatilisation from synthetic fertiliser
$Frac_{GASM}$	0.20	kg NH3-N + NOx-N / (kg N applied or deporsited)	Volatilisation from all organic N fertilisers applied, and dung and urine deposited by grazing animals
$Frac_{LEACH-(H)}$	0.015	kg N / (kg N additions or deposition by grazing animals)	Country-specific value*

All values given above refer to Table 11.3 of the 2006 IPCC Guidelines Volume 4 except for the $Frac_{LEACH-(H)}$ value. The T1 method was applied for 3.D.2.
* Calculations on the country-specific FracLEACH-(H) value of 0.015:
Equation 11.10 is given below;
N2O(L)–N = (FSN + FON + FPRP + FCR + FSOM) • *FracLEACH –(H)* • *EF5*
Where F=(Fsn+Fon+Fprp+Fcr+Fsom),
N2O(L)-N = F * FracLEACH-(H) * EF5
and
N2O(L) = N2O-N * (44/12)
Applying this equation for two different factors of FracLEACH-(H) would result in
for 95% of the total area according to the map given as
N2O(L)-N = F * 0.95 * FracLEACH-(H) * EF5 (where FracLEACH-(H) is 0.00)
and
for 5% of the total area according to the map given as
N2O(L)-N = F * 0.05 * FracLEACH-(H) * EF5 (where FracLEACH-(H) is 0.30)
Please note that FracLEACH-(H) (for 95% of the land area) equals **0.00** and
FracLEACH-(H) (for 5% of the land area) equals **0.30**.

Finding a new weighted average rate for FracLEACH-(H) is as straightforward as follows:
F * FracLEACH-(H)new * EF5 = {[F *0.95] * FracLEACH-(H) * EF5} + {[F * 0.05] * FracLEACH-(H)* EF5}

F * FracLEACH-(H)new * EF5 = {[F *0.95] * **0.00** * EF5} + {[F * 0.05] * **0.30** * EF5}

F * FracLEACH-(H)new * EF5 = { 0.00 } + { [F * 0.05] * 0.30 * EF5}

F * FracLEACH-(H)new * EF5 = { F * 0.015 * EF5 }

FracLEACH-(H)new = 0.015

Emission factors/parameters used in the agriculture sector (continued)

3.F Field Burning of agricultural residues	G_{ef} (g /kg) CH4	N2O	C_f CH4 and N2O	Method	Note
	CH_4	N_2O	CH_4 and N_2O		
3.F.1.a Wheat	2.7	0.07	0.9	T1	
3.F.1.b Barley	2.7	0.07	0.9	T1	C_f value for wheat is used
3.F.1.c Maize	2.7	0.07	0.8	T1	
3.F.1.d Rice	2.7	0.07	0.8	T1	

All values given above refer to Table 2.5 for G_{ef} and Table 2.6 for C_f of the 2006 IPCC Guidelines Volume 4.

3.H Urea Application	EF (tonne of C/ tonne of urea)	Method	Note
Urea fertilisation	0.20	T1	Information given on page 11.32 of the 2006 IPCC Guidelines Volume 4.

Calculated likely emissions level for an estimated rabbit population

Enteric Fermentation

50 000 * 0.24 (kg/head/year) * 28 (GWP) = **0.336 kt CO_2 eq.** (CH_4 emissions)

Manure Management

50 000 * 0.08 (kg/head/year) * 28 (GWP) = **0.112 kt CO_2 eq.** (CH_4 emissions)

Nex = Nrate * (TAM/1000) * 365 = 8.10 * (1.60/1000) * 365 = 4.7304 kg N / head /year

(50 000 * 4.7304 * 100% * 0.005 * (44/28)/10^6) * 265 (GWP) = **0.4925 kt CO_2 eq.** (Direct N_2O emissions)

(50 000 * 4.7304 * 100% * 0.12 * 0.01 * (44/28)/10^6) * 265 (GWP) = **0.1182 kt CO_2 eq.** (Indirect N_2O emissions from atmospheric deposition)

(50 000 * 4.7304 * 100% * 0.045 * 0.0075 * (44/28) / 10^6) * 265 (GWP) = **0.0332 kt CO_2 eq.** (Indirect N_2O emissions from nitrogen leaching and run-off)

The values above add up to a likely emissions level of 1.0919 kt CO_2 eq.

Notes

Enteric fermentation emission factor value of 0.24 is taken as a likely mid-range value from reported IEFs.

For rabbit, methane manure management emission factor is given in Table 10.16 (page 10.41, 2006 IPCC Guidelines, Vol.4) and Nrate is given in Table 10.19 (page 10.59, 2006 IPCC Guidelines, Vol.4).

TAM value is available in Table 10A-9 (page 10.83, 2006 IPCC Guidelines, Vol.4) and references for EF_3, EF_4, EF_5, $Frac_{GASMS}$, $Frac_{LEACHMS}$ values are given above in this Annex.

Manure management solid storage percentage is taken as 100% and 28 and 265 are GWP values from AR5.

Emission factors/parameters used in the waste sector

Category	EF	AD Source
5.A Solid waste disposal	Default values in IPCC 2006, Vol 5, Chp 3	TurkStat's surveys and database Methane recovery facilities
5.B Biological treatment of solid waste 5.B.1 Composting 5.B.1.a Municipal Solid Waste	CH_4: 4, N_2O: 0.24 (IPCC 2006, Vol 5, Chp 4, Table 4.1	TurkStat's surveys and database Composting plants
5.C Incineration and open burning of waste 5.C.2 Open Burning of Waste 5.C.2.1 Biogenic 5.C.2.1.a Municipal Solid Waste	CO_2: OF= 0.58 for MSW (IPCC 2006, Vol 5, Chp 5, Table 5.2) CH_4 & N_2O: Defaults (IPCC 2006, Vol 5, Chp 5, Section 5.4.2 & Table 5.6)	TurkStat's surveys and database
5.D Wastewater treatment and discharge 5.D.1 Domestic Wastewater	Default values (IPCC 2006, Vol 5, Chp 6, Table 6.3 & 6.11) CS BOD values for TOW calculation (as provided below)	TurkStat's surveys and database Methane recovery facilities FAOSTAT
5.D.2 Industrial Wastewater	Default values (IPCC 2006, Vol 5, Chp 6, Table 6.8 & 6.9)	TurkStat's surveys and database

Country-specific BOD values

BOD (g/person/day)	I
Country-specific per capita BOD for wastewater collected by sewers	Correction factor for additional industrial BOD discharged into sewers
53	1

BOD (g/person/day)	BOD (g/person/day)
Country-specific per capita BOD for receiving bodies	Country-specific per capita BOD for sludge removed
25	28

Country specific values for degrees of treatment utilization (T) by income groups

Treatment or discharge system or pathway		T (%)
Rural	To sea, river and lake	0.43
	To aerobic plant, not well managed	0.44
	To septic systems	10.72
Urban	To sea, river and lake	15.43
	To aerobic plant, well managed	44.01
	To aerobic plant, not well managed	1.82
	To anaerobic digester for sludge	20.83
	To septic systems	6.31
Total		100

Annex 5: Completeness

Table A8.1 Completeness, Sources and sinks not estimated ("NE")

GHG	Sector	Source/sink category
CH4	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.b Solid Fuel Transformation
CO2	Agriculture	3.G Liming/3.G.1 Limestone CaCO3
CO2	Agriculture	3.G Liming/3.G.2 Dolomite CaMg(CO3)2
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.1 Underground Mines/1.B.1.a.1.i Mining Activities
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.1 Underground Mines/1.B.1.a.1.ii Post-Mining Activities
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.1 Underground Mines/1.B.1.a.1.iii Abandoned Underground Mines
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.2 Surface Mines/1.B.1.a.2.i Mining Activities
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.2 Surface Mines/1.B.1.a.2.ii Post-Mining Activities
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.b Solid Fuel Transformation
CO2	Energy	1.C CO2 Transport and Storage/Injection and Storage/Injection
N2O	Agriculture	3.1 Livestock/3.B Manure Management/3.B.2 N2O and NMVOC Emissions/3.B.2.5 Indirect N2O Emissions
N2O	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling
N2O	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.b Solid Fuel Transformation
N2O	Industrial Processes and Product Use	2.G Other Product Manufacture and Use/2.G.3 N2O from Product Uses/2.G.3.a Medical Applications
N2O	LULUCF	4.F Other Land/4(III) Direct N2O Emissions from N Mineralization/Immobilization 4.F Other Land
no gas	LULUCF	4.D Wetlands/4.D.2 Land Converted to Wetlands/Carbon stock change/4.D.2.2 Land Converted to Flooded Land/4.D.2.2.2 Cropland converted to flooded land/Carbon stock change in living biomass

Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE")

GHG	Source/sink category	Explanation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Biomass	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Diesel Oil	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Gasoline	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Liquefied Petroleum Gases (LPG)	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Gasoline	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses/Biomass	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses	Included under "1.A.3.e Other Transportation"

Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE")(Cont'd)

GHG	Source/sink category	Explanation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Gasoline	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Gas/Diesel Oil	Included under 1.A.4.c.i
CH4	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Wildfires	Report in "agriculture sector"
CH4	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Wildfires	Report in "agriculture sector"
CH4	4.E Settlements/4.E.1 Settlements Remaining Settlements	included in "agriculture sector"
CH4	4.F Other Land/4.F.2 Land Converted to Other Land	included in "agriculture sector"
CH4	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.1 Biogenic/5.C.1.1.b Other (please specify)/Clinical Waste	Emissions from 5.C.1.1.b Clinical Waste are included in 1.A.1.a
CH4	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.1 Biogenic/5.C.1.1.b Other (please specify)/Industrial Solid Wastes	Emissions from 5.C.1.1.b Industrial Solid Wastes are included in 1.A.1.a, 1.A.2.c and 1.A.2.g
CH4	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Clinical Waste	Emissions from 5.C.1.2.b Clinical Waste are included in 1.A.1.a
CH4	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Industrial Solid Wastes	Emissions from 5.C.1.2.b Industrial Solid Wastes are included in 1.A.1.a, 1.A.2.c and 1.A.2.g
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Biomass	Included under "1.A.3.e Other Transportation"
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Diesel Oil	Included under "1.A.3.e Other Transportation"

Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE")(Cont'd)

GHG	Source/sink category	Explanation
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Gasoline	Included under "1.A.3.e Other Transportation"
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Liquefied Petroleum Gases (LPG)	Included under "1.A.3.e Other Transportation"
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Gasoline	Included under "1.A.3.e Other Transportation"
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses	Included under "1.A.3.e Other Transportation"
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses	Included under "1.A.3.e Other Transportation"
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Gasoline	Included under "1.A.3.e Other Transportation"
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"

Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE")(Cont'd)

GHG	Source/sink category	Explanation
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Gas/Diesel Oil	Included under 1.A.4.c.i
CO2	1.AD Feedstocks, reductants and other non-energy use of fuels/Liquid Fuels/Lubricants	Included under 2D
CO2	2.B Chemical Industry/2.B.8 Petrochemical and Carbon Black Production/2.B.8.b Ethylene	Included in 2.B.8.g
CO2	2.B Chemical Industry/2.B.8 Petrochemical and Carbon Black Production/2.B.8.c Ethylene Dichloride and Vinyl Chloride Monomer	Included in 2.B.8.g
CO2	2.B Chemical Industry/2.B.8 Petrochemical and Carbon Black Production/2.B.8.e Acrylonitrile	Included in 2.B.8.g
CO2	2.C Metal Industry/2.C.1 Iron and Steel Production/2.C.1.b Pig Iron	CO2 emissions from pig iron production is included in emissions from steel production
CO2	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Wildfires	Report in "agriculture sector"
CO2	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Wildfires	Report in "agriculture sector"
CO2	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.1 Biogenic/5.C.1.1.b Other (please specify)/Clinical Waste	Emissions from 5.C.1.1.b Clinical Waste are included in 1.A.1.a
CO2	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.1 Biogenic/5.C.1.1.b Other (please specify)/Industrial Solid Wastes	Emissions from 5.C.1.1.b Industrial Solid Wastes are included in 1.A.1.a, 1.A.2.c and 1.A.2.g
CO2	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Clinical Waste	Emissions from 5.C.1.2.b Clinical Waste are included in 1.A.1.a
CO2	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Industrial Solid Wastes	Emissions from 5.C.1.2.b Industrial Solid Wastes are included in 1.A.1.a, 1.A.2.c and 1.A.2.g
HFC-134a	2.F Product Uses as Substitutes for ODS/2.F.6 Other Applications/2.F.6.a Emissive/HFC-134a	All emissions caused by HFC-134a is given i this section due to lack of disaggregated da Emission estimates are made by tier 1 and default emission factor.

Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE")(Cont'd)

GHG	Source/sink category	Explanation
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Biomass	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Diesel Oil	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Liquefied Petroleum Gases (LPG)	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Gasoline	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses/Biomass	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Gasoline	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Gas/Diesel Oil	Included under 1.A.4.c.i

Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE")(Cont'd)

GHG	Source/sink category	Explanation
N2O	4(IV) Indirect N2O Emissions from Managed Soils/Atmospheric Deposition	No data available
N2O	4.A Forest Land/4.A.1 Forest Land Remaining Forest Land/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers	Direct N2O Emissions from N Inputs to Managed Soils in Forest Land is included in the Agriculture Sector
N2O	4.A Forest Land/4.A.1 Forest Land Remaining Forest Land/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers	No data available
N2O	4.A Forest Land/4.A.2 Land Converted to Forest Land/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers	Direct N2O Emissions from N Inputs to Managed Soils in Forest Land is included in the Agriculture Sector
N2O	4.A Forest Land/4.A.2 Land Converted to Forest Land/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers	Direct N2O Emissions from N Inputs to Managed Soils in Forest Land is included in the Agriculture Sector
N2O	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Wildfires	Report in "agriculture sector"
N2O	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Wildfires	Report in "agriculture sector"
N2O	4.E Settlements/4.E.1 Settlements Remaining Settlements/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers	i.e. included in "agriculture sector"
N2O	4.E Settlements/4.E.1 Settlements Remaining Settlements/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers	i.e. included in "agriculture sector"
N2O	4.E Settlements/4.E.2 Land Converted to Settlements/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers	i.e. included in "agriculture sector"
N2O	4.E Settlements/4.E.2 Land Converted to Settlements/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers	i.e. included in "agriculture sector"
N2O	4.F Other Land/4.F.2 Land Converted to Other Land	included in "agriculture sector"
N2O	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.1 Biogenic/5.C.1.1.b Other (please specify)/Clinical Waste	Emissions from 5.C.1.1.b Clinical Waste are included in 1.A.1.a
N2O	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.1 Biogenic/5.C.1.1.b Other (please specify)/Industrial Solid Wastes	Emissions from 5.C.1.1.b Industrial Solid Wastes are included in 1.A.1.a, 1.A.2.c and 1.A.2.g
N2O	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Clinical Waste	Emissions from 5.C.1.2.b Clinical Waste are included in 1.A.1.a
N2O	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Industrial Solid Wastes	Emissions from 5.C.1.2.b Industrial Solid Wastes are included in 1.A.1.a, 1.A.2.c and 1.A.2.g
N2O	5.D Wastewater Treatment and Discharge/5.D.2 Industrial Wastewater	Emissions from 5.D.2 are included in 5.D.1
SF6	2.G Other Product Manufacture and Use/2.G.1 Electrical Equipment/SF6	
SF6	2.G Other Product Manufacture and Use/2.G.1 Electrical Equipment/SF6	Due to lack of data, NE is entered

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