National Greenhouse Gases Inventory Report

of the

Islamic Republic of Afghanistan

This NIR provides a detailed description of the national GHG emission by sources and removal by sinks for the time series of 1990-2017 for all IPCC sectors, excluding the LULUCF

2019

Afghanistan's National GHG Inventory Report (NIR) 2019

submission under the

United Nations Framework Convention on Climate Change (UNFCCC)

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Disclaimer

We identified many areas for improvements. However, comments and recommendations are always welcome that will help to improve the National GHG Inventory and National Inventory Report (NIR) of the Islamic Republic of Afghanistan. You can send your useful comments to us through schah-zaman@gmx.com

FOREWORD

I am pleased to present the **National Inventory Report (NIR) of Afghanistan** submitted under the United Nations Framework Convention on Climate Change (UNFCCC) for fulfilment of our commitment under Article 4, paragraph 1(a) and Article 12 of the Convention and Decision 1/CP.16.

The **National Inventory Report (NIR) 2019** contains complete information and provides a detailed and comprehensive description of the trend and the methodologies applied in the greenhouse gas inventory for the gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NFH_3). It contains emission data of greenhouse gases by sector for the years 1990 − 2017 as well as detailed information on methodology, emission factors, activity data and other basic data for emission calculations.

The *Special Report on Global Warming* by the Intergovernmental Panel on Climate Change (IPCC) published in 2018 shows that the human-induced global warming has reached 1°C above the pre-industrial average global temperature. However, the South East Asia region, which includes Afghanistan, has already experienced much higher average temperature in some parts. To achieve the objective of the Convention and any related legal instruments such as the Paris Agreement adopted by the Conference of the Parties (COP), *to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner –,* Parties need reliable, transparent and comprehensive information on GHG emissions, climate actions and provided, needed and received support.

To comply with this, Afghanistan prepared the national GHG inventory and the National Inventory Report (NIR) following the quality/guiding principles **transparency, accuracy, completeness, consistency and comparability (TACCC)**. Furthermore, the emissions by sources and removals by sinks are estimated applying of **2006 IPCC Guidelines for National Greenhouse Gas Inventories** and the National Inventory report (NIR) is prepared in the light of the '**Modalities, procedures and guidelines (MPGs) for the transparency framework for action and support referred to in Article 13 of the Paris Agreement**', which will be obligatory from 2024.

Afghanistan's **National Inventory Report (NIR) 2019** would not have been possible without the contribution of valuable data from the government line ministries and agencies. I wish to congratulate all those involved in the process of preparing the **National Inventory Report (NIR) 2019**, particularly the members of the National Study Teams. The report was prepared involving all key stakeholders within multi-disciplinary study teams and through a broad consultative process coordinated by the National Environmental Protection Agency (NEPA).

Finally, I would like to take the opportunity to thank the United Nations Environment Programme and the Global Environment Facility for their financial and technical support for the preparation of this report.

Schah-Zaman Maiwandi
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Climate change in Afghanistan - what does it mean for rural livelihoods and food security? Climate change in Afghanistan is not an uncertain, "potential" future risk but a very real, present threat— whose impacts have already been felt by millions of farmers and pastoralists across the country. (WFP, UNEP & NEPA, 2016)[1].

1.1 Background information on greenhouse gas (GHG) inventory and climate change

1.1.1 Global Warming

According to the fifth assessment report of the IPCC (AR5) and stated in the IPCC special report *Global Warming of 1.5 °C* (SR1.5)[2] human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.

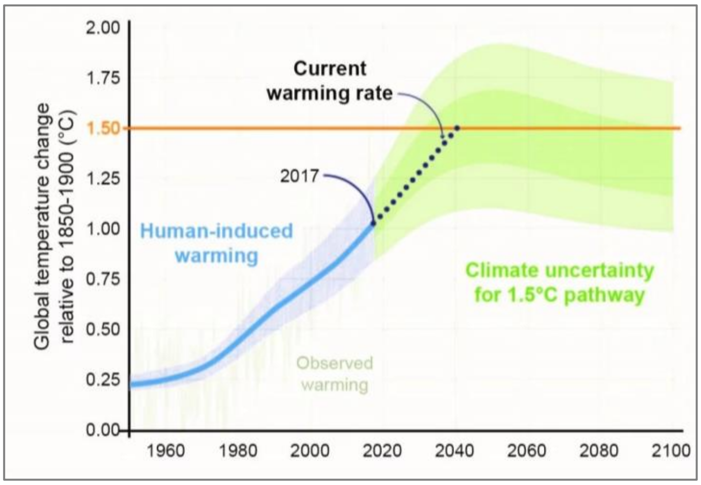


Figure 1 Human-induced warming reached approximately 1°C above pre-industrial levels in 2017.

Source: IPCC (2018): IPCC special report *Global Warming of 1.5 °C* (SR1.5).

As summarized in IPCC special report *Global Warming of 1.5 °C* (SR1.5) the increase of the average surface temperature of the earth will lead to

- differences in regional climate characteristics with
    - changes in climate and weather extremes, temperature extremes on land,
    - risks from droughts and precipitation deficits,
    - global mean sea level rise;
- impacts on biodiversity and ecosystems including species loss and extinction;
- increase in ocean temperature with associated increase in ocean acidity and decreases in ocean oxygen levels;
- climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth;
- needs for adaptation which also includes limited adaptive capacity for some human and natural systems.

[1] World Food Programme (WFP), United Nations Environment Programme (UNEP) & Afghanistan's National Environmental Protection Agency (NEPA) (2016): Climate change in Afghanistan - what does it mean for rural livelihoods and food security? Kabul.
Available (25 May 2019) on https://postconflict.unep.ch/publications/Afghanistan/Afg_CC_RuralLivelihoodsFoodSecurity_Nov2016.pdf

[2] Available (25 May 2019) on https://www.ipcc.ch/sr15/

1.1.2 Climate Change in Afghanistan

Afghanistan is a land-locked and predominantly mountainous country in central Asia with a total area of 647,500 km^2. Most of the land (some 63%) is mountainous and over 27% of the country lies above 2,500 m elevation[3], with extensive plains regions in the southwest lying between 500 and 1,500 m, and the fertile northern plains positioned below 500 m. Afghanistan share boarders with Iran in the west, Tajikistan, Uzbekistan, and Turkmenistan in the north, China in the northeast and Pakistan in the east and south.

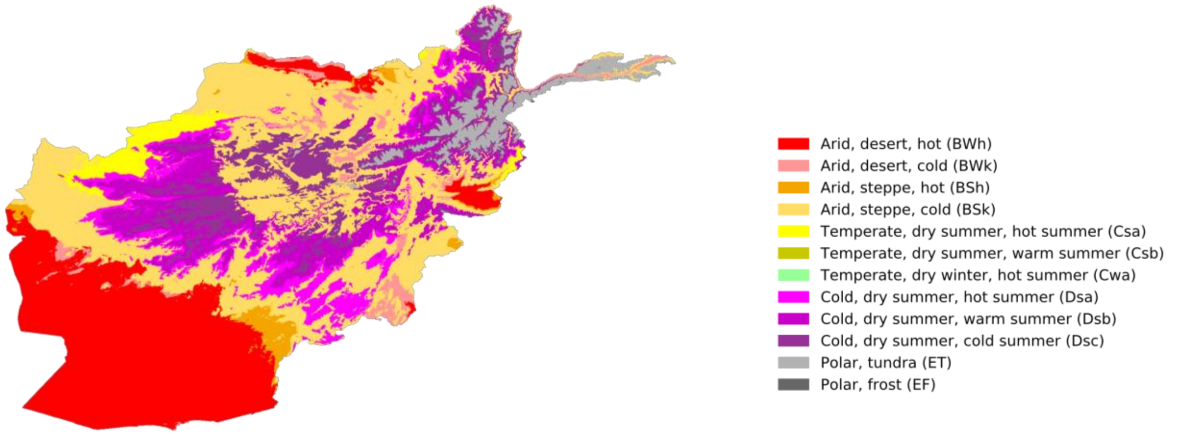
Figure 2: Political boundaries and topography of Afghanistan.

Source: Wikimedia commons; prepared by Sommerkom.[4]

The climate is continental in nature, with cold winters and hot summers. Most of the country is semi-arid or arid, with low amounts of precipitation and high or very high variability between years. Snowfall is concentrated in the central mountains and the higher ranges of the northeast. Winter temperatures are extremely low in both these areas, below - 15ºC for many weeks during winter. Most of Afghanistan is influenced by weather fronts from the Mediterranean, with low and erratic rainfall, typically in spring. The east of the country lies near the margin of the monsoon system affecting the Indian subcontinent. Here, parts of the eastern provinces, including Kunar, Nuristan, Laghman, and Nangarhar, have up to 1 200 mm of rainfall in summer (roughly five times the national average).

[3] United Nations Environment Programme (UNEP). 2003. Post-conflict environmental Assessment: Afghanistan. UNEP, Geneva. Available (20 April 2019) on https://postconflict.unep.ch/publications/afghanistanpcajanuary2003.pdf

[4] Available (20 April 2019) on https://en.wikipedia.org/wiki/Afghanistan



Source: "Present and future Köppen-Geiger climate classification maps at 1-km resolution". Nature Scientific Data. DOI:10.1038/sdata.2018.214

Figure 3: Köppen-Geiger climate classification map for Afghanistan (1980 – 2016)

Source: Wikimedia commons; prepared by Beck, H.E., Zimmermann, N. E., McVicar, T. R., Vergopolan, N., Berg, A., & Wood, E. F (2018).[5]

Within the limitations of available data, the observed climate changes in Afghanistan over the recent past (1960 – 2008) include:

- an increase in both the rate of incidence and the duration of drought periods[6];
- an increase in the mean annual temperature by 0.6°C since 1960, with an average change of 0.13°C per decade[6];
- an increase in the frequency of hot days and nights by 25 days per year (an additional 6.8%)[6];
- spring precipitation decreased (by up to a third) while winter precipitation slightly increased[7]; and
- an increase in seasonal variation in precipitation at a regional level, in the form of extreme snowfall, floods and droughts.

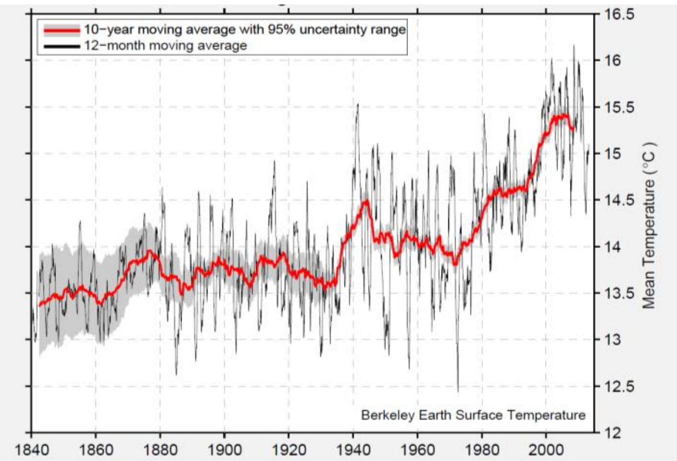


Figure 4 Regional Climate Change: Afghanistan

Source: Berkeley Earth (Eds.)(2015): Berkeley Earth Surface Temperature. [8]

[5] Available (20 April 2019) on https://en.wikipedia.org/wiki/File:Koppen-Geiger_Map_AFG_present.svg

[6] Government of the Islamic Republic of Afghanistan (GIRoA)(2009): National Capacity Needs Self-Assessment for Global Environmental Management (NCSA) and National Adaptation Programme of Action for Climate Change (NAPA). Kabul.
Available (20 April 2019) on Kabul. https://unfccc.int/resource/docs/napa/afg01.pdf

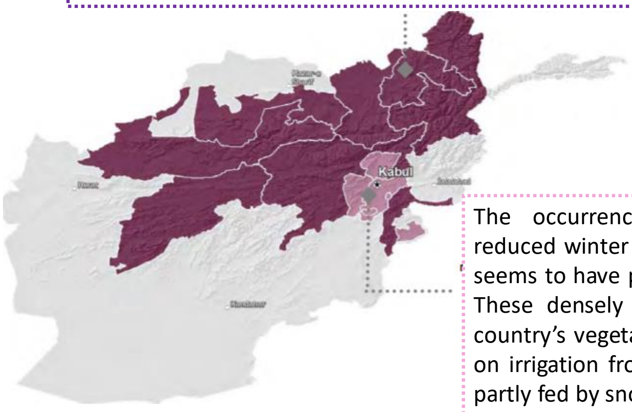
[7] Government of the Islamic Republic of Afghanistan (GIRoA)(2017): Afghanistan's Second National Communication (SNC). Kabul.
Available (20 May 2019) on https://unfccc.int/documents/195778

[8] Available (28 May 2019) on http://berkeleyearth.lbl.gov/auto/Regional/TAVG/Figures/afghanistan-TAVG-Trend.pdf

The joined report from WFP, UNEP & NEPA[9] presents how drought and flood risks have changed Afghanistan over the past thirty years, and what impact this has had on rural livelihoods and food security in the country. *The poorest people—particularly subsistence farmers and pastoralists who are often already living on marginal land—are also those who suffer most from climate change. Yet it is difficult to get an overall, national-level understanding of where the impact of climate change on food security and livelihoods are most worrying and need to be addressed most urgently.*

Drought

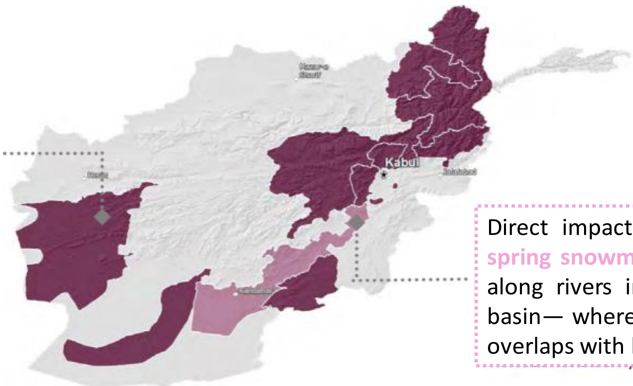
While the climatic risk of **rainfall-related drought** has increased over the past thirty years across most of the country, the main areas of concern in terms of negative impacts on food security are concentrated in the north and parts of the Central Highlands. These are areas where the dominant livelihoods—rainfed farming and pastoralism— are highly dependent on rainfall, and where the observed decline in spring rainfall therefore has a direct impact on households' ability to produce food and earn income.



The occurrence of **snowmelt-related drought**—caused by reduced winter snowfall in parts of the Hindu Kush mountains—seems to have primarily affected Kabul and surrounding regions. These densely populated areas, which produce much of the country's vegetables, fruits and cereals —are heavily dependent on irrigation from the Kabul river and its tributaries, which are partly fed by snowmelt from the Hindu Kush.

Floods

Negative impacts of **floods caused by heavy spring rainfall** have been felt across a range of different livelihood zones – from the mountainous areas in the north-east and centre of the country, to the hilly border areas in the southeast, all the way down to the flat, arid southern provinces. These are zones where heavy precipitation events have increased by 10 to 25% in the past thirty years, and where livelihoods are dominated by agriculture and pastoralism—both highly sensitive to flooding.



Direct impacts of **riverine floods caused by increased spring snowmelt** **in** the spring seem to be concentrated along rivers in the eastern part of the Helmand river basin— where increased risk of snowmelt– related floods overlaps with high livelihood vulnerability to flooding.

Source: World Food Programme (WFP), United Nations Environment Programme (UNEP) & Afghanistan's National Environmental Protection Agency (NEPA) (2016): Climate change in Afghanistan - what does it mean for rural livelihoods and food security?

[9] World Food Programme (WFP), United Nations Environment Programme (UNEP) & Afghanistan's National Environmental Protection Agency (NEPA) (2016): Climate change in Afghanistan - what does it mean for rural livelihoods and food security?
Available (28 May 2019) on https://cdn.wfp.org/wfp.org/publications/WFP_UNEP_NEPA_Afghanistan_Impacts_climate_%20change.pdf?

The climate projections for the period 2021– 2050 predicted for Afghanistan

- further increased drought risk: in many parts of the country annual droughts will likely become the norm;
- further increased flood risk.

The climate projections for the period 2021– 2050 were prepared using the Cordex South Asia regional climate models[10]. The above mentioned results are based on the selected 'moderate emissions scenario', known as *Representative Concentration Pathways 4.5* (RCP4.5), which assumes that global greenhouse gas emissions will continue to increase until 2040 and then decrease, and that temperatures will continue to increase until 2100 to around 2 °C, and then plateau thereafter.

1.1.3 Convention, Kyoto Protocol and Paris Agreement

Afghanistan became a Party to the UN Framework Convention on Climate Change (UNFCCC) as Non-Annex I Party in 2002, accede the Kyoto Protocol in 2013 and ratified the Paris Agreement in 2017. In the following paragraphs the key massages of the convention and Kyoto Protocol and Paris agreement are presented as on the website of UNFCCC.

- The **UN Framework Convention on Climate Change (UNFCCC)** is a "Rio Convention", one of three adopted at the "Rio Earth Summit" in 1992. Its sister Rio Conventions are the UN Convention on Biological Diversity and the Convention to Combat Desertification. Preventing "dangerous" human interference with the climate system is the ultimate aim of the UNFCCC.[11]
- The **Kyoto Protocol** is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets. Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of "common but differentiated responsibilities.[12]
- The **Paris Agreement** builds upon the Convention and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.[13]

In the following tables are presented

- the Convention, Kyoto Protocol and Paris Agreement with the dates of entry into force and the current status.
- the submissions – reports and data sets – under the UN Framework Convention on Climate Change.

[10] Available (28 May 2019) on http://www.cordex.org/domains/region-6-south-asia-2/

[11] Link to and Text of the United Nations Framework Convention on Climate Change; available (12 January 2019) on https://unfccc.int/process/the-convention/what-is-the-convention/status-of-ratification-of-the-convention

[12] Link to and Text of the Kyoto Protocol; available (12 January 2019) on https://unfccc.int/process/the-kyoto-protocol/status-of-ratification

[13] Link to and Text of the Paris Agreement; available (12 January 2019) on https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

Table 1 Status of signature and ratification by Afghanistan of the UNFCCC, Kyoto Protocol and Paris Agreement

	Entry into force	Status (07/2019)	Afghanistan	
			Signature	Ratification
United Nations Framework Convention on Climate Change (UNFCCC)	21 March 1994	197 Parties	12 June 1992	19 September 2002
Kyoto Protocol *to the UNFCCC* (First commitment period 2008-2012)	16 February 2005	192 Parties	-	25 March 2013 a
Doha Amendment[14] *to the Kyoto Protocol* (Second commitment period 2013-2020)		130 Parties		
Copenhagen Accord[15]			Intention to be signatory[16]	
Paris Agreement *to the UNFCCC*	4 November 2016	184 Parties	22 April 2016	15 February 2017

Remark: Ratification, Acceptance(A), Accession(a), Approval(AA)

Table 2 Status of Afghanistan's submission of the National Communication (NC), Biennial Update Report (BUR) and Nationally Determined Contribution (NDC)

UNFCCC Reporting obligation	National Communication (NC) submission	Biennial Update Report (BUR) submission	GHG inventory (tables) as part of NC and BUR - *(Time series) based on*		National Inventory Report (NIR)	(Intended) Nationally Determined Contribution (INDC) / (NDC)
			1996 revised IPCC GL & IPCC Good Practice Guidance (GPG)	2006 IPCC Guidelines		
NC1 = INC	12 Mar 2013[17]		X (2005) UNFCCC software			
NC2	25 May 2019[18/19]		X (2013) UNFCCC software			
NC3	Planned for 2023					
1st BUR		in preparation **- current project -**		BUR (2012 – 2017) NIR (1990 – 2017) (MS Excel based; IPCC software only for QC checks)	Stand-alone report	
2nd BUR		Planned for 2023				
First INDC						13 October 2015[20]
First NDC						23 November 2016[35] Qualitative commitment
Second NDC						Planned for2021

INC - Initial National Communication

[14] Link and Text of the Doha amendment; available (12 January 2019) on https://unfccc.int/files/kyoto_protocol/application/pdf/kp_doha_amendment_english.pdf

[15] Link to and text of the Copenhagen Accord: FCCC/CP/2009/11/Add.1, 2/CP.15; available (12 January 2019) on https://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf

[16] Available (12 January 2019) on https://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/afghanistancphaccord_app2.pdf

[17] Available (12 January 2019) on https://unfccc.int/documents/67354; https://unfccc.int/sites/default/files/resource/afgnc1_0.pdf

[18] Available (12 January 2019) on https://unfccc.int/documents/195778; https://unfccc.int/sites/default/files/resource/SNC%20Report_Final_20180801%20.pdf

[19] Available (12 January 2019) on https://postconflict.unep.ch/publications/Afghanistan/Second_National_Communication_Report2018.pdf http://www.acbar.org/upload/148041673828.pdf

[20] Available (12 January 2019) on https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/Afghanistan/1/INDC_AFG_Paper_En_20150927_.docx%20FINAL.pdf

The Convention divides countries into three main groups according to differing commitments:

Annex I Parties	The industrialized countries that were members of the OECD (Organization for Economic Co-operation and Development) in 1992 and listed in Annex I to the Convention. They include the 24 original OECD members, the European Union, and 14 countries with economies in transition (EIT).
Annex II Parties	Consist of the OECD members of Annex I, but not the EIT Parties.
Non-Annex I Parties	Refers to countries that have ratified or acceded to the United Nations Framework Convention on Climate Change that are not included in Annex I of the Convention.

1.2 A description of the institutional arrangements

As a Party to the Convention and according the Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention, section III[21], non-Annex I Parties

Para 6. shall, in accordance with Article 4, paragraph 1 (a), and Article 12, paragraph 1(a) of the Convention, communicate to the Conference of the Parties a national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, to the extent its capacities permit, following the provisions in these guidelines.

Para 7. shall estimate national GHG inventories for the year 1994 for the initial national communication (INC) or alternatively may provide data for the year 1990. For the second national communication (SNC), non-Annex I Parties shall estimate national GHG inventories for the year 2000. The least developed country Parties could estimate their national GHG inventories for years at their discretion.

Therefore, Afghanistan is required to produce regularly a National Greenhouse Gas Inventories. The First National Communication (INC) was prepared for the year 2005, the Second National Communication (SNC) was prepared for the year 2012. The National Greenhouse Gas Inventory prepared for the First Biennial Update Report (BUR) and this National Inventory Report (NIR) covers the years 1990 to 2017.

A National Inventory Report (NIR) containing detailed and complete information on the inventory, in order to ensure the transparency of the inventory, the two relevant Guidelines provide the following guidance:

(1) Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention, section B, non-Annex I Parties,

Para 13. are encouraged to describe procedures and arrangements undertaken to collect and archive data for the preparation of national GHG inventories, as well as efforts to make this a continuous process, including information on the role of the institutions involved.

Para 21. are encouraged to provide information on methodologies used in the estimation of anthropogenic emissions by sources and removals by sinks of GHG not controlled by the Montreal Protocol, including a brief explanation of the sources of emission factors and activity data. If non-Annex I Parties estimate anthropogenic emissions and removals from country specific sources and/or sinks which are not part of the IPCC Guidelines, they should explicitly describe the source and/or sink categories, methodologies, emission factors and activity data used in their estimation of emissions, as appropriate. Parties are encouraged to identify areas where data may be further improved in future communications through capacity-building.

(2) UNFCCC biennial update reporting guidelines for Parties not included in Annex I to the Convention

Para 9. The inventory section of the biennial update report should consist of a national inventory report as a summary or as an update of the information contained in chapter III (National greenhouse gas inventories) of the annex to decision 17/CP.8, including table 1, on “National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and greenhouse gas precursors”, and table 2, on “National greenhouse gas inventory of anthropogenic emissions of HFCs, PFCs and SF6”.

Therefore, Afghanistan prepared

- a comprehensive chapter “National Greenhouse Gas Inventory” in the first BUR, covering the period 2012 to 2017, and
- a standalone report ‘Afghanistan’s National Inventory Report (NIR) 2019’, covering the period 1990 to 2017.

[21] Available (30 January 2019) on FCCC/CP/2002/7/Add.2, section III., paragraph 6.

1.2.1 Overview of legal, institutional, and procedural arrangements for compiling GHG inventory

In the following figure the MRV framework for the GHG inventory of Afghanistan is illustrated. In the following (sub-)chapters below a description of the various roles and responsibilities is provided.

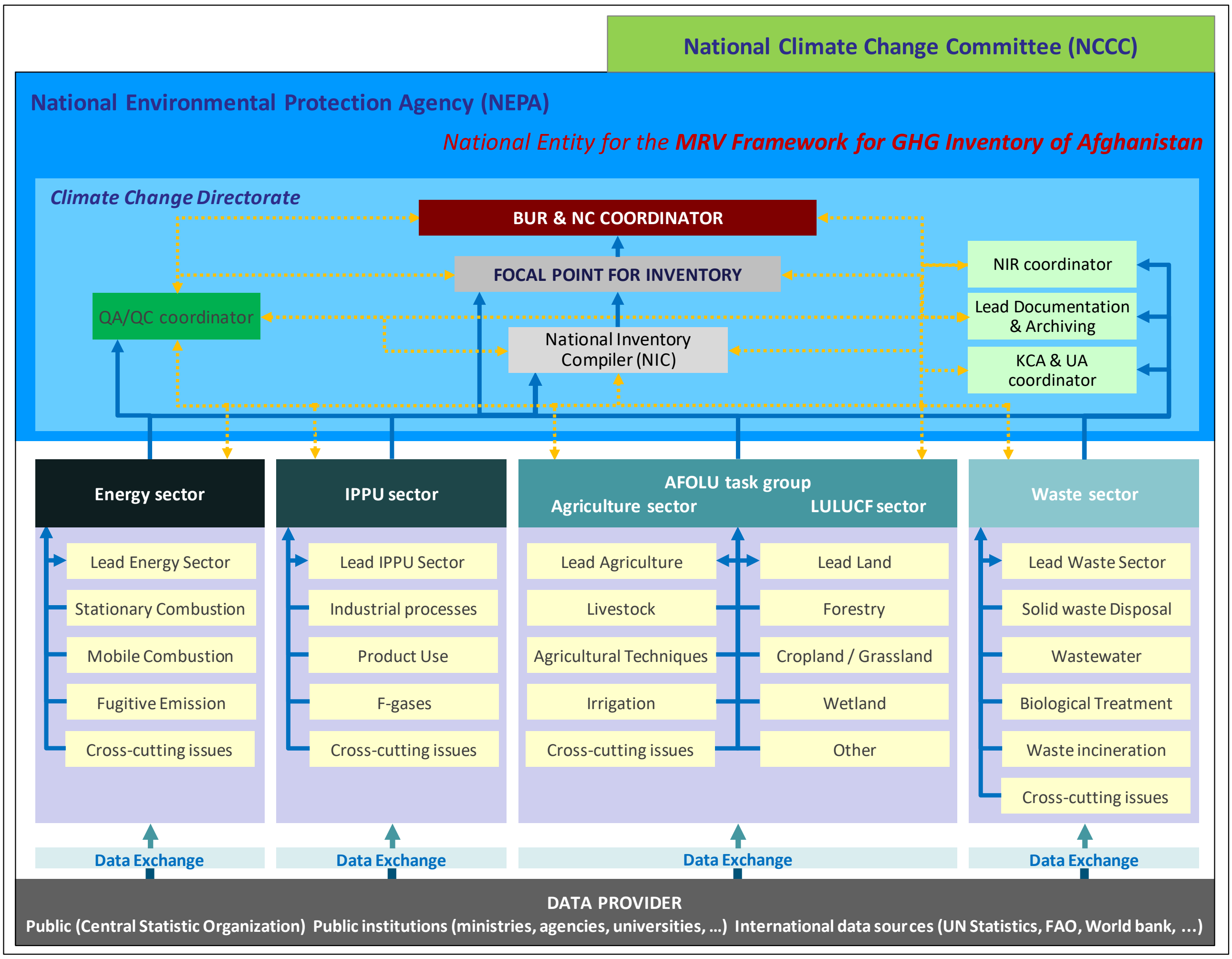


Figure 5 MRV Framework for the GHG Inventory of Afghanistan

(1) Emissions and removals **shall** be estimated by ***sector experts*** for

(a) all sectors of the GHG inventory according to the 2006 IPCC guidelines

- IPCC sector 1 Energy
- IPCC sector 2 Industrial Processes and Product Use (IPPU)
- IPCC sector 3 Agriculture
- IPCC sector 4 Land Use, Land Use Change and Forestry (LULUCF)
- IPCC sector 5 Waste
- IPCC sector 6 Other

AFOLU – Agriculture, Forestry and Other Land Use - is divided into two 'sectors' but with close linkage.

(b) all seven gases of the GHG inventory according to the 2006 IPCC guidelines

- carbon dioxide (CO_2)
- methane (CH_4),
- nitrous oxide (N_2O),
- hydrofluorocarbons (HFCs),
- perfluorocarbons (PFCs),
- sulphur hexafluoride (SF6), and
- nitrogen trifluoride (NF3).

(2) Emissions should be estimated by sector experts for

- carbon monoxide (CO),
- nitrogen oxides (NOx)
- non-methane volatile organic compounds (NMVOCs),
- sulphur oxides (SOx).

Table 3 Overview on reporting obligation

	Greenhouse gases (GHG)							Air pollutants																						
				F-gases				Main pollutants Precursors					Particulate matter (PM)				Persistent organic pollutants (POPs)					Heavy Metals (HMs) Priority HMs			Additional HMs					
	CO_2	N_2O	CH_4	SF_6	HFC	PFC	NF_3	SO_x	NOx	NMVOC	CO	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	PCDD/ PCDF	HCB	DIOX	PAH	PCB	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
IPCC Sectors																														
1. Energy																														
2. Industrial processes and product use (IPPU)																														
AFOLU 3. Agriculture																														
AFOLU 4. LULUCF																														
5. Waste																														
6. Other																														
Reporting obligtion																														
UNFCCC - Greenhouse gas (GHG) inventory under the Convention, the Kyoto protocol and under the Paris Agreement																														
Data																														
National Inventory report (NIR)																														
Short-lived climate pollutants (SLCPs)																														
Climate and Clean Air Coalition																														
Stockholm Convention																														
National reports																														

Remark: polycyclic aromatic hydrocarbons (PAHs) reported as {benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene,Total 1-4}

Remark

- According to Decision 17/CP.8 - Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention Non-Annex I Parties are encouraged to provide information relating to HFCs, PFCs, SF6.
- According to Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement: para 48. Each Party shall report seven gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF6 and NF3); those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead report at least three gases (CO_2, CH_4 and N_2O) as well as any of the additional four gases (HFCs, PFCs, SF6 and NF3) that are included in the Party's NDC under Article 4 of the Paris Agreement, are covered by an activity under Article 6 of the Paris Agreement, or have been previously reported. (https://unfccc.int/sites/default/files/resource/cp24_auv_transparency.pdf)

1.2.1.1 Legal arrangements for compiling GHG inventory

The legal basis for the preparation of the National GHG inventory is the **Environment Law**[22] adopted in 2007 (Law Official Gazette No 912 dated 25 January 2007). The **National Environmental Protection Agency (NEPA)** is carrying out according to **Article 9** the following functions and powers:

(3) coordinate environmental affairs at the local, national and international levels;

(7) implement bilateral or multilateral environmental agreements to which Afghanistan is a Party;

(9) sign on behalf of the government agreements regarding the protection and rehabilitation of the environment;

(10) promote and manage the Islamic Republic of Afghanistan's accession to and ratification of bilateral and multilateral environmental agreements;

(11) coordinate the preparation and implementation of a national programme for environmental monitoring and effectively utilize the data provided by that programme;

(15) periodically compile and publish reports on significant environmental indicators.

Within the National Environmental Protection Agency (NEPA) the **Department of Climate Change Mitigation DCCM)**, which belongs to the Directorate of Climate Change Mitigation and Adaptation, is responsible for the preparation of National GHG Inventory and National Inventory Report (NIR).

The directorates and departments of NEPA, which are involved as data provider, highlighted in the figure below.

The NEPA is represented and managed by an Executive Director. The organizational chart of NEPA is presented in the following Figure.

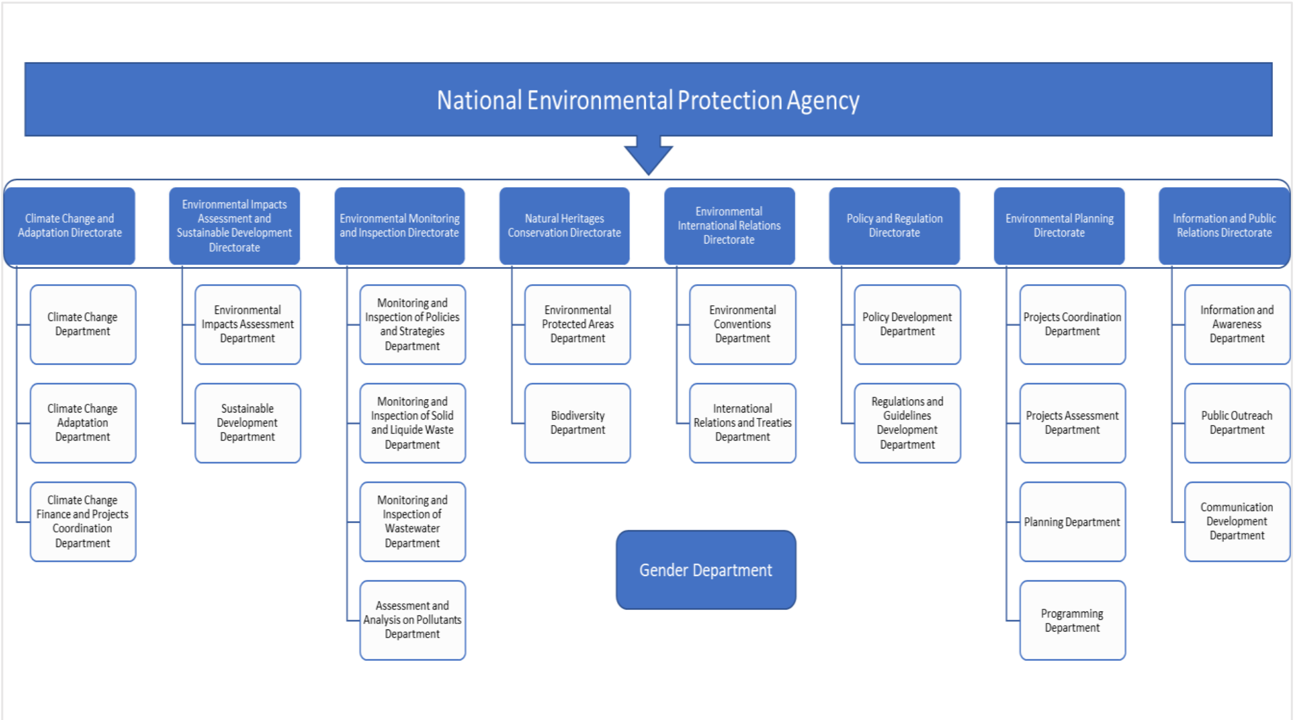


Figure 6 Organizational Chart of the National Environmental Protection Agency (NEPA) with responsibilities related to GHG inventory preparation

[22] Available (30 January 2019) on http://old.moj.gov.af/Content/files/OfficialGazette/0901/OG_0912.pdf

1.2.1.2 Institutional arrangements for compiling GHG inventory

As stipulated in para 7 and 9 of the above mentioned article 9 of the Environment Law the National Environmental Protection Agency (NEPA) shall to implement bilateral or multilateral environmental agreements and shall to coordinate the preparation and implementation of a national programme for environmental monitoring and effectively utilize the data provided by that programme.

As such NEPA is acting as **National Entity** with overall responsibility for the national inventory.

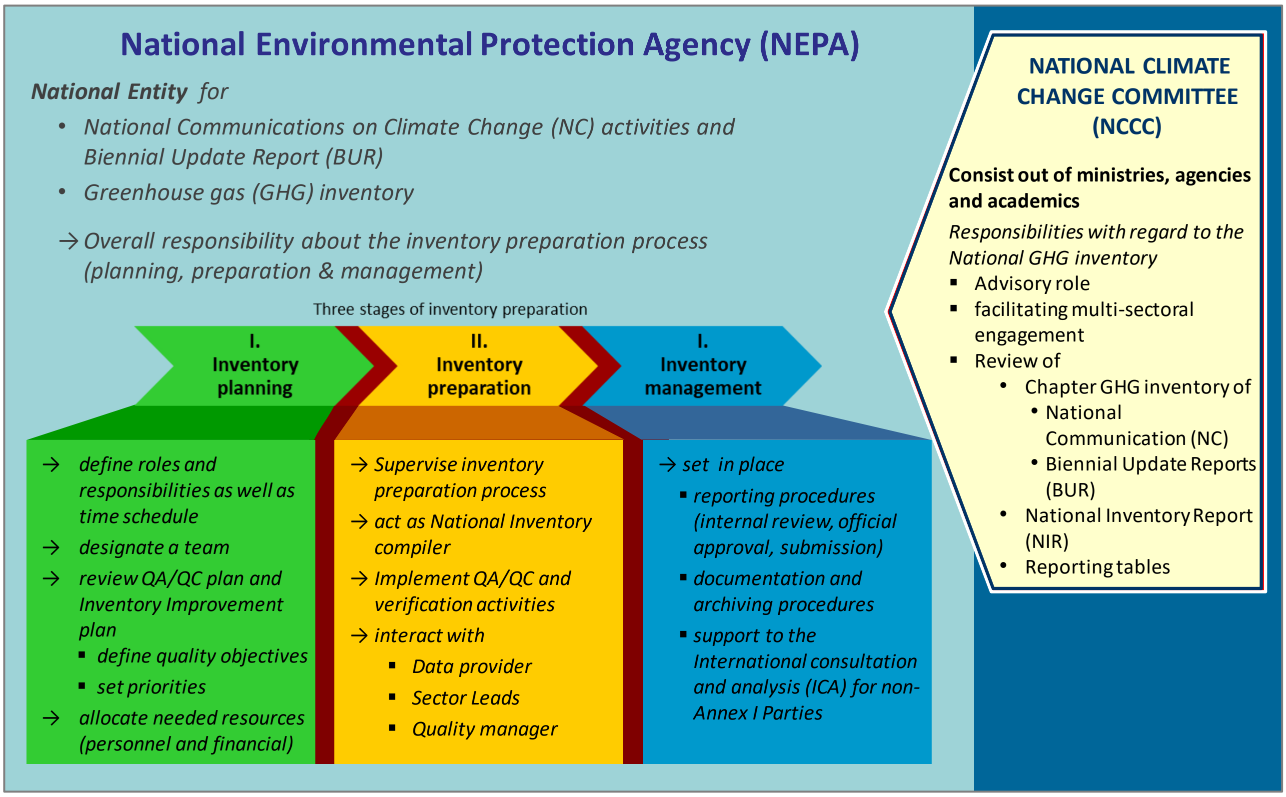


Figure 7 National Entity for Greenhouse Gas (GHG) Inventory.

1.2.1.2.1 National Entity[23]

(1) The **National entity** with overall responsibility for the national inventory is responsible to monitor, report and review information relevant to the implementation of the United Nations Framework Convention on Climate Change (UNFCCC).

(2) The **Director General** of the National Environmental Protection Agency, in his authority and duties, is head of National Entity. The **responsibilities** of the National entity are in detail

a. prepares and submits information related to	In place
i. greenhouse gas (GHG) emissions,	In place
ii. actions taken to reduce GHG emissions;	In place
b. ensures the overall management of the national MRV system for GHG gas emissions and removals including its improvement;	In place
c. designates and supports the Focal point GHG inventory;	In place
d. designates - after consultation with the *Focal point GHG inventory* and upon proposal, if necessary, by members of other Ministries and Institutions involved in the GHG inventory, the	Partly in place
i. ***sector experts*** for estimating the GHG emissions and removals;	Partly in place
ii. ***QA/QC coordinator*** for the GHG inventory;	Not in place
e. designates - after consultation with the *Focal point for GHG inventory* respectively, and upon proposal, if necessary, by members of other Ministries and Institutions involved in the GHG inventory preparation process, specific **roles** for the GHG inventory, the:	Partly in place
i. **National Inventory Compiler (NIC)**/data manager	Partly in place
ii. Key category Analysis (KCA) & Uncertainty analyses (UA) coordinator	Partly in place
iii. National Inventory Report (NIR) coordinator	Partly in place
iv. Data provider	In place
f. ensures the	In place
i. **approval** of draft inventories including related methodological reports;	In place
ii. that the inventory and as soon as they are approved, and related methodological reports are **submitted to the competent international body / UNFCCC**.	In place
(3) For each function, listed under (2), two persons shall be appointed:	Not in place
a. Two sector experts (SE) form the sector team, whereas one team member is nominated as team leader (Sector Lead – SL);	Not in place
b. Each other function has a Lead and deputy.	Not in place

[shaded]	*In place.*	[hatched]	*Partly in place.*	[grid]	*Not in place.*

[23] This role and relevant responsibilities need to be approved.

1.2.1.2.2 National Climate Change Committee (NCCC)[24]

As stipulated in para 19 of the above mentioned article 9 of the Environment Law the National Environmental Protection Agency (NEPA) shall/should actively coordinate and cooperate with ministries, Provincial Councils and District and Village Councils, public bodies and the private sector on all issues related to sustainable use of natural resources and conservation and rehabilitation of the environment. As such NEPA is coordinating **National Climate Change Committee (NCCC)** which consist out of ministries, agencies and academics.

The National Climate Change Committee (NCCC) should facilitate multi-sectoral engagement and that ensures inter- and intra-ministerial coordination. The overall responsibility of the National Climate Change Committee (NCCC) *with regard to the National GHG inventory* is an advisory role, undertakes reviews of the draft Chapter 'GHG inventory' of the National Communication (NC) and Biennial Update Reports (BUR) as well as the National Inventory Report (NIR) including Reporting tables and provides recommendation.

As stated in the 2006 IPCC guidelines, Volume 1: *General Guidance and Reporting*, Chapter 2: Approaches to Data Collection, it is strongly recommended to work together with National Statistics Agencies, the statistical service and relevant department of line ministries, not only to protect confidentiality, but also for cost savings. Therefore, the members of the National Climate Change Committee are important **data providers**. Ancillary data which are collected during operations for other purposes by different ministries and national institutions, are oftentimes needed as activity data and/or parameter as well as for verification.

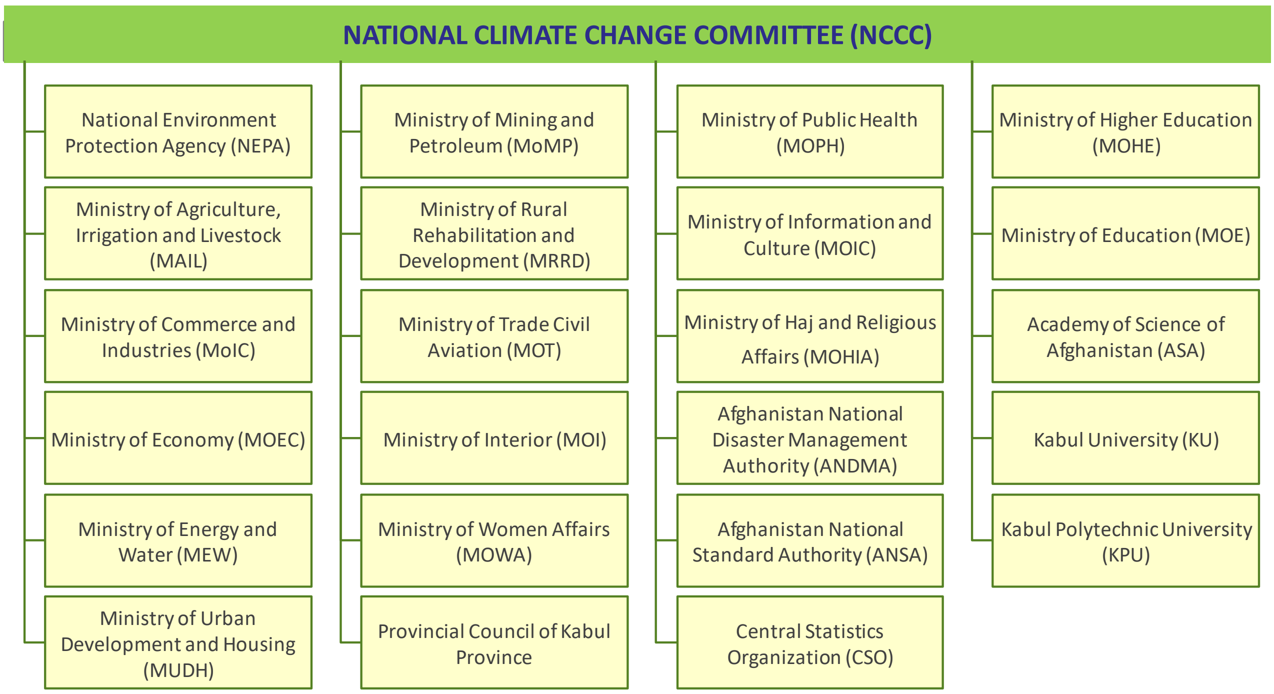


Figure 8 Members of the National Climate Change Committee of Afghanistan

[24] Check here for completeness of list of tasks; this role and relevant responsibilities needs to be approved.

1.2.1.2.3 Focal Point for GHG Inventory[25]

The *Focal point GHG inventory* is responsible for the following tasks:

a.	to ensure the transparency, accuracy, consistency, comparability and completeness (TACCC) of the GHG inventory as well as timeliness of the preparation process;	Partly in place
b.	to inform *sector experts* and related institutions about any changes in the methodology of the - 206 IPCC Guidelines - Guidelines for National Greenhouse Gas Inventories prepared by the Intergovernmental Panel on Climate Change (IPCC) and evaluate, together with *sector experts*, the impact of these changes in calculation methodology and estimates of emissions and removals;	Partly in place
c.	to assist *sector experts* in their work;	Partly in place
d.	to support and monitor the implementation of the quality policy and quality objectives;	Not in place
e.	to promote of quality awareness and making sure that the importance of complying with legal and official requirements is generally understood;	Not in place
f.	to define, depending on national and international reporting deadlines, a timetable for the submission of the different elements necessary for the preparation of the GHG inventory and the related methodological report, and to ensure compliance with this timetable;	Not in place
g.	to set up a sustainable (IT) system for documenting and archiving of all information relating to the GHG inventory, and to ensure the reproducibility of the related data;	Not in place
h.	to develop appropriate approaches for collecting activity data, emission factors and other relevant data and parameters, to validate selected emission and removal factors, and carry out, in collaboration with the *QA/QC coordinator*, quality control and quality assurance throughout the whole inventory preparation process;	Partly in place
i.	to prepare the Key Category Analyses (KCA) and Uncertainty Analysis (UA) and related assessment;	Partly in place
j.	to estimate emissions and/or removals for a given sector where the sector expert does not submit the data and information necessary to prepare the inventory within the time frame defined in the above-mentioned timetable;	Partly in place
k.	to compile all data and information and related methodological reports in that format required for submission, using own IT tools and/or those set up by IPCC and UNFCCC, respectively;	Partly in place
l.	to coordinate external audits, especially the International consultation and analysis (ICA) of the UNFCCC, update - in close collaboration with the *sector experts* and *QA/QC coordinator* – the inventory improvement plan containing all recommendations resulting from these audits and ensure their appropriate implementation;	Not in place
m.	to provide the *National Entity* with information regarding (i) management and status of the GHG inventory and (ii) potentials and needs to improve the GHG inventory;	Partly in place
n.	to report to the *National Entity* any problems that may affect the well-functioning of the MRV for GHG Inventory of Afghanistan with regards to the GHG inventory.	Partly in place

	In place.		*Partly in place.*		*Not in place.*

[25] This role and relevant responsibilities need to be approved.

1.2.1.2.4 Sector experts[26]

(1) Emissions and removals **shall** be estimated by ***sector experts*** for

(a) all sectors of the GHG inventory according to the 2006 IPCC guidelines

(b) all seven gases of the GHG inventory according to the 2006 IPCC guidelines

(2) Emissions of air pollutants (precursors) should be estimated by sector experts.

(3) The *sector experts* are responsible for the following tasks:

a.	to choose appropriate methodology for the estimation of emissions and removals, which have to be in line with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and other requirements;	
i.	non-key categories are usually estimated using a simple, so called Tier 1 approach	
ii.	key categories are estimated using a more detailed methodology (Tier 2 approach or Tier 3 approach), which usually also means country specific.	
b.	to define, where necessary in consultation with the institutions referred to in Table 5, the activity data, emission factors and other relevant parameters necessary for the estimation of emissions and removals;	
c.	to estimate emissions and removals in accordance with the reporting guidelines of the UNFCCC in force and presented above;	
d.	to estimate emissions and removals for sub-categories falling within their sector(s), where the institution does not provide emissions or removals and related information of that sub-category;	
e.	to recalculate emissions and removals of previous submission; where necessary, especially due to the following reasons:	
i.	refinement or changes in methods	
ii.	ICA/review/audit recommendations according to the inventory improvement plan,	
iii.	new sources of information, refinement or changes in activity data	
iv.	error corrections;	
f.	to estimate and calculate uncertainties associated with activity data, emission factors and emissions and removals;	
g.	to ensure the application/implementation of quality assurance and quality control (QA/QC and verification activities related to the used data and estimates and provided in the inventory quality assurance/quality control (QA/QC) plan;	
h.	to ensure the timeliness, transparency, accuracy, consistency, comparability and completeness of the used data and estimates;	
i.	to prepare the chapter of the methodological reports related to their sector(s) and provide information requested for crosscutting issues (Applied method, KCA, Uncertainty, completeness, Trend, Improvement and & recalculation);	
j.	to participate actively in ICA/reviews/audits, prepare answers to reviews, auditors' questions and forward them to the Focal point GHG inventory within the given deadlines;	

[26] This role and relevant responsibilities need to be approved.

k. to provide the Focal point GHG inventory and the QA/QC Coordinator Inventory with information regarding (i) management and status of the GHG inventory and (ii) potentials and needs to improve the inventory;	
l. to inform the Focal point GHG inventory and the QA/QC Coordinator Inventory of any problems arising during the GHG inventory preparation process and that may affect the well-functioning the **MRV for GHG Inventory** of Afghanistan.	

	In place.		*Partly in place.*		*Not in place.*

1.2.1.2.5 Data provider - provision of activity data and other relevant information[27]

(1) All data (e.g. activity data, emission factors, emissions, other relevant parameter) and information necessary for the estimation of emissions and removals **shall** be provided to the *sector experts* by the institutions listed in **Table 5 Overview of general and sectoral competences and roles for the preparation of the inventory**.

(2) *Sector experts* and *Focal point for GHG inventory* define - in consultation with the data provider - quality standards and formats of data and data provision as well as deadlines for data provision as outlined in **Table 4 Provision of activity data and other relevant information**.

(3) This includes data coming from statistics, inventories, modelling exercises, national and international projects, research results or other data sources established by these institutions.

In meetings with data providers the sector experts are explaining the intended use of the data and the level at which the data will be made public. The meetings are also intended to ensure that the inventory experts learn from the data providers how they collect and process the relevant data and, if necessary, report the data to other national or international institutions. A cooperation of inventory experts and data provider may lead to mutually acceptable data set.

Along the key points listed in the following table a **source-specific data collection template** is prepared and shared with the relevant data provider.

[27] This role and relevant responsibilities need to be approved.

Table 4 Provision of activity data and other relevant information

Topics to be discussed with and agreed on data provider				Documented
Restricted data and confidentiality[28]	protection of confidentiality is one of the fundamental principles of a national statistical agency; this is **also** fundamental principle for emission inventories, projections			
Definition of the data set	**IPCC sectors and sub-sector detail**			
	national coverage			
	time series	starting point	1990	
		time series[29]	1990 to x-2	
		pillar years	1990, 1995, 2000, 2005, 2010	
	activity data units	"base" unit (in which the data are collected)		
		conversion factors		
Definition of the format spreadsheet	**format**	electronic	excel spreadsheet	
			pdf or word	
			Scan	
		hard copy		
	structure of table(s)	following international reporting format e.g. UN statistics – energy questionnaire, FAO questionnaire		
		following national format	questionnaire to plant operator, farmers, customs, etc.	
Description of any assumptions made regarding	national coverage			
	sectors included			
	representative year			
	technology/ management level			
Type of data	survey data	already existing surveys		
		new surveys		
	census data			
	Literature			
	measurement data			
	expert judgement			
Identification of the routines and timescales for data collection activities	how often is the data set updated			
	what elements are updated			
Reference to documentation				
QA/QC procedures				
Data availability				

based on: 2006 IPCC Guidelines, Volume 1: General Guidance and Reporting (GGR), Chapter 2: Approaches to Data Collection https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_2_Ch2_DataCollection.pdf

[28] explaining the intended use of the data; agreeing, in writing, to the level at which it will be made public; identifying the increased accuracy that can be gained through its use in inventories; offering cooperation to derive a mutually acceptable data set

[29] x-2: current year minus 2: e.g. current year 2019: time series 1990 - 2017

Table 5 Overview of general and sectoral competences and roles for the preparation of the inventory (submission 2019)

Sector	Required information	Competent authorities (preliminary)	Role	Status
Calculation sheets IPCC Software database		National Environmental Protection Agency (NEPA)	**National Inventory Compiler (NIC)**	
QA/QC activities		NEPA	**QA/QC coordinator**	
Key Category Analysis Uncertainty Analysis		NEPA	**KCA & UA coordinator**	
National Inventory Report (excluding sectoral chapter)		NEPA	**NIR coordinator**	
Archiving		NEPA	**Lead archiving**	
Energy (Stationary fuel combustion)		NEPA	**SECTOR EXPERT**	
	National Energy Balance	Central statistics organization (CSO) / National Statistics and Information Authority (NSIA) Ministry of Mines and Petroleum (MoMP) Ministry of Energy and Water (MEW) Ministry of Finance (MoF) - customs	data provider	
	Fuel specific information	Ministry of Mines and Petroleum (MoMP), Da Afghanistan Breshna Sherkat (DABS)	data provider	
	Fuel quality reports	Afghan national standard authority (ANSA)	data provider	
	Net caloric value (NCV)	MoMP	data provider	
	Environmental Plant permit data (Environmental Impact Assessment (EIA))	National Environmental Protection Agency (NEPA)	data provider	
	Data of Energy purchase agreement – (fuel consumption)	Da Afghanistan Breshna Sherkat (DABS)	data provider	
	Refinery input & output	Ministry of Mines and Petroleum (MoMP) Ministry of Commerce and Industries (MoCI)	data provider	
Energy – Transport (Mobil fuel combustion)		*Need to be determined*	**SECTOR EXPERT**	
	National Energy Balance	CSO/NSIA (see above)	data provider	
	Fuel specific information	MoMP (see above)	data provider	
	Fuel quality reports	MoMP / MoTI (see above)	data provider	
	Net caloric value (NCV)	MoMP (see above)	data provider	

Sector	Required information	Competent authorities (preliminary)	Role	Status
	Aviation • Aircraft fleet • Landing, taxi, (LTO) • Origin / Destination / Registered carrier departures • distance • ATC (Air Traffic Control) records • Air passengers carried • Air freight	Civil Aviation Authority of Afghanistan *administrative units of the* Ministry of Transport (MOT) Central statistics organization (CSO) / National Statistics and Information Authority (NSIA)	data provider	
	Road transport • Vehicle Fleet information • Vehicle category (passenger car, LDV, HDV, busses, Motorcycle) • Type: petrol, diesel, LPG, CNG • Legislation/technology (PRE ECE, ECE ##, Improved conventional, Open loop, Euro 1, 2,3,4,5,6, etc.) • road transport - data specific to infrastructures and networks	• National Road Authority • Traffic Authority • Highway Transportation Authority *administrative units of the* Ministry of Transport (MOT) Ministry of Public Works and Transport (MoPW) Central statistics organization (CSO) / National Statistics and Information Authority (NSIA)	data provider	
	Rail transport • Fleet – locomotive type and engine size • railway transport - data specific to infrastructures and networks	Afghanistan Railway Authority *administrative units of the* Ministry of Transport (MOT)	data provider	
	Off-road / agriculture • fleet composition • engine type / size	Ministry of Public Works and Transport (MoPW) Ministry of Agriculture Irrigation and Livestock (MAIL)	data provider	
IPPU (excluding F-gases)		National Environmental Protection Agency (NEPA)	**SECTOR EXPERT**	
	Production statistics	Central statistics organization (CSO) / National Statistics and Information Authority (NSIA)	data provider	
	Import & Export statistics	Central statistics organization (CSO) / National Statistics and Information Authority (NSIA) Ministry of Finance (MoF) - customs	data provider	
	Environmental Plant permit data (environmental Impact assessment EIA))	National Environmental Protection Agency (NEPA)	data provider	
	Plant specific data	Plant operator	data provider	

Sector	Required information	Competent authorities (preliminary)	Role	Status
IPPU (only F-gases)		National Environmental Protection Agency (NEPA)	**SECTOR EXPERT**	
	Production statistics	Central statistics organization (CSO) / National Statistics and Information Authority (NSIA)	data provider	
	Import & Export statistics	Central statistics organization (CSO) / National Statistics and Information Authority (NSIA) Ministry of Finance - customs	data provider	
	Database for Montreal Protocol / Kigali Agreement under the Montreal Protocol	National Environmental Protection Agency (NEPA)	data provider	
	Vehicle fleet data – road transport	Traffic Authority *administrative unit of the* Ministry of Transport (MOT)	data provider	
Agriculture		Ministry of Agriculture Irrigation and Livestock (MAIL) *Need to be determined*	**SECTOR EXPERT**	
	Livestock • species • Weight, milk yield, fat content, working time • manure management practices	Ministry of Agriculture Irrigation and Livestock (MAIL) Central statistics organization (CSO) / National Statistics and Information Authority (NSIA) Independent Directorate of Local Governance (IDLG)	data provider	
	Cultivated and harvested crops and Rice cultivation • area • yield • practices	Ministry of Agriculture Irrigation and Livestock (MAIL) Central statistics organization (CSO) / National Statistics and Information Authority (NSIA) Independent Directorate of Local Governance (IDLG)	data provider	
	Fertilizer consumption	Ministry of Agriculture Irrigation and Livestock (MAIL) Central statistics organization (CSO) / National Statistics and Information Authority (NSIA) Independent Directorate of Local Governance (IDLG)	data provider	

Sector	Required information	Competent authorities (preliminary)	Role	Status
Land Use, Land Use Change and Forestry (LULUCF)		Ministry of Agriculture Irrigation and Livestock (MAIL) *Need to be determined*	**SECTOR EXPERT**	
	National land classification system applicable to all six land-use categories (Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land) and further subdivide by climate, soil type and/or ecological regions.	Ministry of Agriculture Irrigation and Livestock (MAIL) Central statistics organization (CSO) / National Statistics and Information Authority (NSIA) National Environmental Protection Agency (NEPA)	data provider	
	Information on Forest • Forest inventory and/or forest management system/Area of plantation/forests • Area annually affected by disturbances including frequency of disturbances (pest and disease outbreaks, flooding, fires, etc.). • Area annually affected by harvest; • (Intensification of) forest management activities (i.e. site preparation, tree planting and rotation length changes; changes in harvesting practices • Harvested Wood Products: Waste deposit, sawn wood, wood panels, paper, energy purpose	Ministry of Agriculture Irrigation and Livestock (MAIL) Central statistics organization (CSO) / National Statistics and Information Authority (NSIA) National Environmental Protection Agency (NEPA) Independent Directorate of Local Governance (IDLG) Ministry of Rural Rehabilitation and Development (MRRD)	data provider	
	Information on Cropland • arable and tillable land, rice fields, and agroforestry systems • annual and perennial crops as well as temporary fallow land • crop-pasture rotation (mixed system) • land areas of growing stock and harvested land with perennial woody crops	Ministry of Agriculture Irrigation and Livestock (MAIL) Central statistics organization (CSO) / National Statistics and Information Authority (NSIA)	data provider	
	Information on Grassland and Wetland	Ministry of Agriculture Irrigation and Livestock (MAIL) Central statistics organization (CSO) / National Statistics and Information Authority (NSIA)	data provider	
	• Information on Settlements	Ministry of Agriculture Irrigation and Livestock (MAIL) Central statistics organization (CSO) / National Statistics and Information Authority (NSIA)	data provider	

Sector	Required information	Competent authorities (preliminary)	Role	Status
Waste		NEPA	**SECTOR EXPERT**	
	Waste • Waste generation • Waste composition • Waste management practices • Number & size of landfills	Central statistics organization (CSO) / National Statistics and Information Authority (NSIA) National Environmental Protection Agency (NEPA) Ministry of Rural Rehabilitation and Development (MRRD) Independent Directorate of Local Governance (IDLG) Kabul Municipality	data provider	
	Wastewater • Wastewater treatment practices • Wastewater treatment plants	Central statistics organization (CSO) / National Statistics and Information Authority (NSIA) National Environmental Protection Agency (NEPA) Ministry of Rural Rehabilitation and Development (MRRD) Independent Directorate of Local Governance (IDLG) Kabul Municipality	data provider	

	In place.		*Partly in place.*		*Not in place.*

1.2.1.2.6 Support by United Nations Environment Programme (UNEP)

United Nations Environment Programme (UNEP) is the United Nations systems designated entity for addressing environmental issues at the global and regional level. Its mandate is to coordinate the development of environmental policy consensus by keeping the global environment under review and bringing emerging issues to the attention of governments and the international community for action.

The United Nations Environment Programme (UNEP) Crisis Management Branch, established in 1999 and based in Geneva, provides environmental assistance to post-conflict countries by, among other things, providing capacity building and technical assistance for post-conflict environmental administrations.

Since 2002, UN Environment has taken an active role in laying the environmental foundations for sustainable development in Afghanistan. […] UN Environment's Afghanistan programme focuses on building environmental resilience and sustainability throughout the country through:[30]

(1) Strengthening environmental governance and building institutions;
(2) Providing technical assistance in fulfilling the administrative obligations of each ratified convention;
(3) Putting in place robust knowledge management and environmental outreach activities;
(4) Developing community-based natural resources management;
(5) Preserving the country's diverse landscape.

The current GHG inventory and National Inventory report (NIR) is prepared under the overall project '**Umbrella Programme for Biennial Update Report (BUR) to the United National Framework Convention on Climate Change (UNFCCC)**'[31] which was set up to support 39 Small Island Developing States (SIDS) and Least Developed Countries (LDCs) countries in preparing the Biennial Update Reports (BURs) in order to meet their development planning needs and convention reporting requirements. The project is funded by the Global Environment Facility (GEF) and the implementing agency is UNEP.

The components of the overall projects are

1) National circumstances, institutional arrangements for the preparation of the national communications on a continuous basis;
2) **National inventory of anthropogenic emissions by sources and removal by sinks of GHGs;**
3) Information on mitigation actions and their effects, including associated methodologies and assumptions;
4) Financial, technical and capacity needs including support needed and received;
5) Domestic measurement reporting and verification;
6) Any other information;
7) Monitoring, reporting and preparation financial audit;
8) Publication and submission of BURs.

In this context UNEP supports the National Environmental Protection Agency (NEPA) as designated agency responsible for fulfillment the reporting obligation und der UNFCCC requested provision of on-going capacity building support over 4 years, including a new project on Climate Change that aims to build national capacity and create platforms to compile the greenhouse gases data.

[30] Available (30 January 2019) on https://www.unenvironment.org/explore-topics/disasters-conflicts/where-we-work/afghanistan
[31] Available (30 November 2018) on https://www.thegef.org/sites/default/files/project_documents/BUR__CEO_Endorsement_Request_15.04.2015_0.pdf

The main focus of one component of the above-mentioned project is

- to prepare the greenhouse gas inventory for the time series 1990 - 2017;
- to strengthen Afghanistan's institutional arrangements and methodological capacity for the regular preparation of the country's GHG inventory.

This includes the establishment of a sustainable national inventory system, which includes

- a capable inventory team as part of the National Study Team members with specific responsibilities;
- trained sector experts as part of the National Study Team members;
- the use of methods according to the 2006 IPCC guidelines;
- data collection arrangements and archiving system;
- the application of Quality Assurance and Quality Control procedures.

Through national and international support it was possible to prepare a transparent, complete, accurate, consistent and comparable preparation of the GHG inventories according to the current UNFCCC requirements and in the light of the 'Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement' which will be in place from 2024 onwards:

- Application of 2006 IPCC Guidelines for National Greenhouse Gas Inventories;
- Preparation of a GHG inventory of the entire time series and National Inventory Report (NIR) according to the principles listed in section *B. Guiding principles* para 3:
  (a) Building on and enhancing the transparency arrangements under the Convention, recognizing the special circumstances of the least developed countries (LDCs) and small island developing States (SIDS), and implementing the transparency framework in a facilitative, non-intrusive, non-punitive manner, respecting national sovereignty and avoiding placing undue burden on Parties;
  (b) The importance of facilitating improved reporting and transparency over time;
  (c) Providing flexibility to those developing country Parties that need it in the light of their capacities;
  (d) Promoting transparency, accuracy, completeness, consistency and comparability;
  (e) Avoiding duplication of work and undue burden on Parties and the secretariat;
  (f) Ensuring that Parties maintain at least the frequency and quality of reporting in accordance with their respective obligations under the Convention;
  (g) Ensuring that double counting is avoided;
  (h) Ensuring environmental integrity.

It is high priority to provide support in a way that leads to sustainable and ongoing improvement in the reporting of GHG inventories.

During the inventory preparation process, national sector experts and the international consultant collect activity data, emission factors and all relevant information needed for estimating the emissions. National data and international data were compared and a consistent set of activity data and parameter for the period 1990 – 2017 was prepared.

National Sector experts and data provided were also responsible for performing Quality Control (QC) activities that are incorporated in the QA/QC plan. All data collected together with emission estimates are archived on a central archiving system, together with the well documented data sources in order to be able to perform future reconstructions of the inventory.

1.2.1.2.7 Planned improvements with regard to legal, institutional, and procedural arrangements

In chapter 1.2.1.2.1 to chapter 1.2.1.2.5 the legal, institutional, and procedural arrangements as well as roles and responsibilities for compiling the greenhouse gas inventory of Afghanistan are presented. The chosen approach is very comprehensive and detailed. Currently not all arrangements are in place and/or implemented as well as not all roles and responsibilities have already been implemented. Therefore, the current status is provided.

	In place.		*Partly in place.*		*Not in place.*

With regard to the national system the following improvements and the corresponding resources needed were identified to make these improvements effective, are presented in following tables.

Table 6 Planned improvements identified in regard to the National System

GHG source & sink category	Planned improvement	Type of improvement	Priority
Roles and Responsibilities	Tailor-made training / In-house training for all roles and responsibilities as outlined in chapter 1.2.1.2.1 to chapter 0	National system	High
Roles and Responsibilities	Identification of general and sectoral competences and roles	National system	High
Data provider	Identification of data provider (plant operator)	National system	High
Quality Assurance & Quality Control and verification	Tailor-made training / In-house training on Quality Assurance & Quality Control and verification according to the 2006 IPCC Guidelines, Chapter 6 • Quality objectives: TACCC - Transparency, Accuracy, Completeness, Comparability, Consistency • QA/QC plan • Roles and Responsibilities • QA/QC activities during the inventory preparation process • Verification • Archiving	National system	High
Uncertainty Analysis	Tailor-made training / In-house training on Uncertainty Analysis according to the 2006 IPCC Guidelines, Chapter 3 • Causes of uncertainty • Quantifying Uncertainties • Sources of data and information • Techniques for quantifying uncertainties • Methods to combine uncertainties • Reporting and Documentation of Uncertainties	National system	medium
Archiving and reporting	Tailor-made training / In-house training on archiving and reporting • Non-Annex-I (NAI) Reporting tables • National Inventory Report (NIR) • Archive / Archiving	National system	High
Data management	Computer skills training - Intensive/tailor-made training/hands-on-exercises • Advanced Excel Training - Formulas & Functions, large dataset • Advanced word training – working with large, complex documents • Data management	Transparency National system	High
ICA	Tailor-made training / In-house training on supporting as Inventory team the International Consultation and Analysis (ICA)	National system	High

Table 7 Sector-specific planned improvements identified in regard to the National System

GHG source & sink category	Planned improvement	Type of improvement	Priority
Energy	*The availability of good, reliable and timely basic energy statistics and energy balances is fundamental for the estimation of GHG emissions and to address the global concerns for climate change. (UNSD 2018)* Intensive/tailor-made training for preparation of energy statistics / balances (e.g.) • in-house by UNSD, • participation in international (examples) ○ Energy Statistics Courses by International Energy Agency (IEA)[32] ○ Trainings on Energy Statistics by Joint Organizations Data Initiative (JODI) ○ Training by the South Asian Association for Regional Cooperation (SAARC) ○ participation in webinars and online training programmes	Increased capacity of involved ministries and institution including regional offices (e.g.) • Ministry of Mines and Petroleum MoMP • Ministry of Energy and Water (MEW) • National Statistics and Information Authority (NSIA) • DABS Da Afghanistan Breshna Sherkat	High
Energy - Road transport & Off-road	Intensive/tailor-made training for estimation of non-CO_2 emissions and non-GHG emissions from road transport and off-road with a tool like HBEFA, ARTEMIS, COPERT, MOVES and PARAMIX model • in-house / tailor-made training on a model for estimating emission from road transport and off-road • participation in international trainings	Increased capacity of involved ministries and institution including regional offices (e.g.) • Ministry of Transport (MoT) • Ministry of Mines and Petroleum (MoMP) • National Statistics and Information Authority (NSIA) • National Environmental Protection Agency (NEPA)	High
IPPU - F-gases	Intensive/tailor-made training for estimation of GHG emissions from the import, use, maintenance, recycling and destruction of F-gas containing products/installations	Increased capacity of involved ministries and institution • National Environmental Protection Agency (NEPA) • Ministry of Finance – customs • National Statistics and Information Authority (NSIA)	High
Agriculture	Intensive/tailor-made training for estimation of GHG emissions from Livestock Husbandry and Management Practice, soil cultivation	Increased capacity of involved ministries and institution • Ministry of Agriculture Irrigation and Livestock (MAIL) • National Environmental Protection Agency (NEPA) • National Statistics and Information Authority (NSIA)	High
Training on LULUCF	Intensive/tailor-made training for estimation of GHG emissions from LULUCF • Land definition and classification • Land cover mapping • Estimation of GHG of each land use category	Increased capacity of involved ministries and institution • Ministry of Agriculture Irrigation and Livestock (MAIL) • National Environmental Protection Agency (NEPA) • National Statistics and Information Authority (NSIA)	High

[32] Available (25 February 2019) at: https://www.iea.org/statistics/?country=WORLD&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES

GHG source & sink category	Planned improvement	Type of improvement	Priority
Training on Waste	Intensive/tailor-made training for estimation of GHG emissions from • Solid waste disposal • Wastewater treatment	Increased capacity of involved ministries and institution • National Environmental Protection Agency (NEPA) • National Statistics and Information Authority (NSIA) • Ministry of Rural Rehabilitation and Development (MRRD) • Independent Directorate of Local Governance (IDLG)	High

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1.3 Inventory preparation

The greenhouse gas inventory of Afghanistan for the period 1990 to 2017 was compiled according to the recommendations for inventories set out in the

- Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention. Decision 17/CP.8 (FCCC/CP/2002/7/Add.2)[33];

  Non-Annex I Parties are required to submit their first National Communication (NC) within three years of entering the Convention, and every four years thereafter. The NCs shall be prepared in accordance with the guidelines contained in decision 17/CP.8.

  III. NATIONAL GREENHOUSE GAS INVENTORY

  6. Each non-Annex I Party shall, in accordance with Article 4, paragraph 1 (a), and Article 12, paragraph 1(a) of the Convention, communicate to the Conference of the Parties a national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, to the extent its capacities permit, following the provisions in these guidelines.
  7. Non-Annex I Parties shall estimate national GHG inventories for the year 1994 for the initial national communication or alternatively may provide data for the year 1990. For the second national communication, non-Annex I Parties shall estimate national GHG inventories for the year 2000. The least developed country Parties could estimate their national GHG inventories for years at their discretion.

- UNFCCC biennial update reporting guidelines for Parties not included in Annex I to the Convention (Decision 2/CP.17, FCCC/CP/2011/9/Add.1, Annex III[34])

  Non-Annex I Parties, consistent with their capabilities and the level of support provided for reporting, should submit their first Biennial Update Report (BUR) by December 2014, and every two years thereafter. The least developed country Parties and small island developing States may submit BURs at their own discretion. The BURs shall be prepared in accordance with the guidelines contained in.

  III. National greenhouse gas inventory

  3. Non-Annex I Parties should submit updates of national GHG inventories according to paragraphs 8–24 in the "Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention" (hereinafter referred to as the UNFCCC guidelines for the preparation of national communications from non-Annex I Parties) as contained in the annex to decision 17/CP.8. The scope of the updates on national GHG inventories should be consistent with capacities, time constraints, data availabilities and the level of support provided by developed countries Parties for biennial update reporting.

The current National GHG Inventory and National Inventory Report (NIR) of the Islamic Republic of Afghanistan for the period 1990 – 2017 has been prepared also in the light of the 'Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement'[35] which will be in place from 2024 onwards:

- Application of 2006 IPCC Guidelines for National Greenhouse Gas Inventories;
- Preparation of the NIR according to the principles listed in section B. Guiding principles para 3:

[33] Available (21 February 2019) on FCCC/CP/2002/7/Add.2 https://unfccc.int/sites/default/files/17_cp.8.pdf

[34] Available (21 February 2019) on FCCC/CP/2011/9/Add.1, Annex III. https://unfccc.int/sites/default/files/resource/docs/2011/cop17/eng/09a01.pdf

[35] Available (21 February 2019) on https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Afghanistan%20First/INDC_AFG_20150927_FINAL.pdf

(a) Building on and enhancing the transparency arrangements under the Convention, recognizing the special circumstances of the least developed countries (LDCs) and small island developing States (SIDS), and implementing the transparency framework in a facilitative, non-intrusive, non-punitive manner, respecting national sovereignty and avoiding placing undue burden on Parties;

(b) The importance of facilitating improved reporting and transparency over time;

(c) Providing flexibility to those developing country Parties that need it in the light of their capacities;

(d) Promoting transparency, accuracy, completeness, consistency and comparability;

(e) Avoiding duplication of work and undue burden on Parties and the secretariat;

(f) Ensuring that Parties maintain at least the frequency and quality of reporting in accordance with their respective obligations under the Convention;

(g) Ensuring that double counting is avoided;

(h) Ensuring environmental integrity.

In the following Figure the current reporting and review obligations and the reporting and review obligations under the Paris Agreement (current status of negotiations) are presented. A biennial reporting and review of the greenhouse gas inventory and National Inventory Report (NIR) will be status.

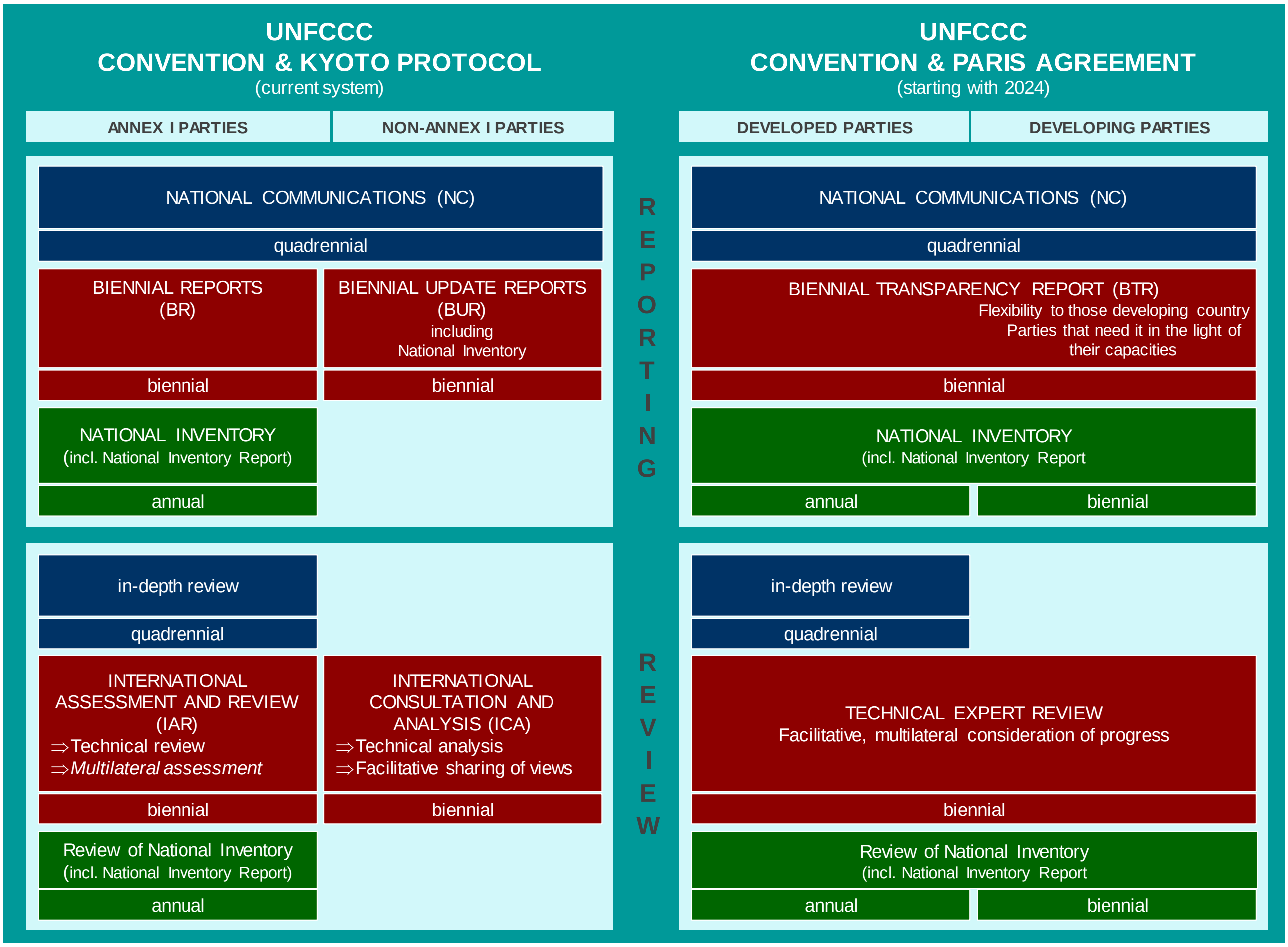

Figure 9 Comparison of the current reporting and review obligations and the reporting and review obligations under the Paris Agreement (current status of negotiations).

Source: Köther, Traute (2019): Comparison of the current reporting obligations and the reporting obligations under the Paris Agreement. Based on After WRI (2017): Designing the Enhanced Transparency Framework, Part 2: Review under the Paris Agreement.

1.4 Brief general description of methodologies and data sources used

The main sources for activity data are national and international statistics like UNSD and FAO. While for the historical period 1990 – 2008 only international data were used, for the recent years mainly national data could be used. In order to fill gaps expert judgement based on discussion with relevant national experts is applied.

The main sources for emission factors of GHG are the 2006 IPCC Guidelines. For the emission factors of air pollutants, the EMEP/EEA air pollutant emission inventory guidebook 2016 is used. Country-specific (CS) emission factors were driven for the estimation of GHG emission from electricity production, cement production as well as enteric fermentation and manure management of cattle.

For key categories, the most accurate methods for the preparation of the greenhouse gas inventory should be used. Due to lack of data and resources, it was not possible to estimate all emissions according to the sectoral decision trees. Where the methodological choice is not in line with the sectoral decision tree, actions are defined and listed in the inventory improvement plan.

The following table briefly presents the activity data (AD) sources, the types of emission factors (EF) used, and the methods applied for estimating GHG emissions reported in this NIR. Detailed information on applied methodology, used activity data (AD) and emission factors (EF) are presented in the relevant sectoral chapters.

The preparation of the inventory starts always with identification of the key categories of the previous inventory followed by the selection of the appropriate identify the appropriate method for estimation for each category according to the **decision tree** of each source presented in Volume 2 – 5 of the 2006 IPCC guidelines. In the following Figure the general Decision Tree to choose a **Good Practice method** is presented.

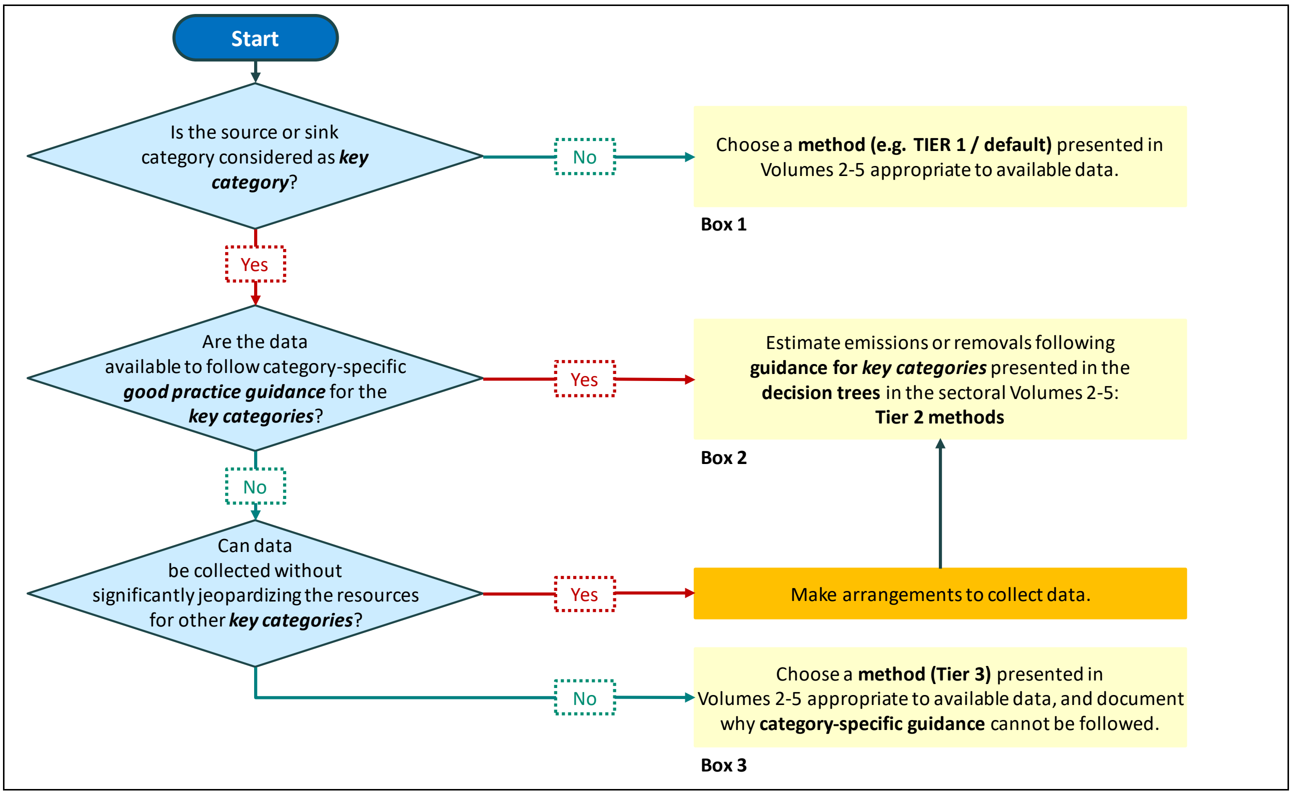

Figure 10 Decision Tree to choose a Good Practice method

Source: 2006 IPCC guidelines, Vol. 1: General Guidance and Reporting, Chap. 1: Introduction to the 2006 Guidelines, sub-chap. 4.1.2 Purpose of the key category analysis, Figure 4.1, p. 4.6.

Table 8 Summary report for methods and emission factors used and source of activity data

Greenhouse gas source and sink categories	CO_2			CH_4			N_2O		
	Method applied	Emission factor	Activity data	Emission factor	Emission factor	Activity data	Emission factor	Emission factor	Activity data
1. Energy									
A. Fuel combustion									
1. Energy industries	T1	CS	PS/Q/NSIA/UNSD	T1	D	PS/Q/NSIA/UNSD	T1	D	PS/Q/NSIA/UNSD
2. Manufacturing industries and construction	T1	D	NSIA/UNSD	T1	D	NSIA/UNSD	T1	D	NSIA/UNSD
3. Transport	T1	D	NSIA/UNSD	T1	D	NSIA/UNSD	T1	D	NSIA/UNSD
4. Other sectors	T1	D	NSIA/UNSD	T1	D	NSIA/UNSD	T1	D	NSIA/UNSD
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE	NE
B. Fugitive emissions from fuels									
1. Solid fuels	T1	D	NSIA/UNSD				T1	D	NSIA/UNSD
2. Oil and natural gas	T1	D	NSIA/UNSD				T1	D	NSIA/UNSD
2. Industrial Processes and Product Use (IPPU)									
A. Mineral products	T2	CS	CS/NSIA/UNSD						
B. Chemical industry	T1	D	NSIA/UNSD	T1	D	NSIA/UNSD	NO	NO	NO
C. Metal production	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Other production	T1	T1	NSIA/UNSD				NO	NO	NO
E. Production of halocarbons and SF6	NO	NO	NO						
F. Consumption of halocarbons and SF6	NE	NE	NE						
G. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture									
A. Enteric fermentation				T1/T2	D/CS	NSIA/CS/FAO			
B. Manure management				T1/T2	D/CS	NSIA/CS/FAO	T1	D	NSIA/CS/FAO
C. Rice cultivation				T1	D	NSIA/FAO			
D. Agricultural soils				T1	D	NSIA/FAO	T1	T1	NSIA/CS/FAO
E. Prescribed burning of savannahs				NO	NO	NO	NO	NO	NO

Greenhouse gas source and sink categories	CO_2			CH_4			N_2O		
	Method applied	Emission factor	Activity data	Emission factor	Emission factor	Activity data	Emission factor	Emission factor	Activity data
F. Field burning of agricultural residues				T1	D	NSIA/FAO	T1	T1	NSIA/CS/FAO
G. Other (Urea application)	T1	D	NSIA/FAO						
4. Land-use, Land-use change and forestry (LULUCF)									
Land-use, Land-use change and forestry (LULUCF)	NE	NE	NE	NE	NE	NE	NE	NE	NE
5. Waste	T1	D		T1	D	NSIA/CS/UNSD/ALCS/EJ	T1	D	NSIA/CS/ALCS/EJ
A. Solid waste disposal on land				T1	D	NSIA/CS/UNSD/ALCS/EJ			
B. Waste-water handling				T1	D	NSIA/CS/UNSD/ALCS/EJ	T1	D	NSIA/CS/ALCS/EJ
C. Waste incineration	T1	D	NSIA/CS/UNSD/ALCS/EJ	T1	D	NSIA/CS/UNSD/ALCS/EJ	T1	D	NSIA/CS/ALCS/EJ
D. Other - Composting	T1	D	NSIA/CS/UNSD/ALCS/EJ	T1	D	NSIA/CS/UNSD/ALCS/EJ			
6. Other									
Other	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items									
International bunkers									
Aviation	T1	D	NSIA/UNSD	T1	D	NSIA/UNSD	T1	D	NSIA/UNSD
Marine	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass									
CO_2 emissions from biomass	T1	D	NSIA/CS/UNSD/FAO/ALCS/EJ						

Notation keys	
NA	Not applicable
NO	Not occurring
NE	Not estimated
IE	Included elsewhere
C	Confidential

Notation keys to specify the method applied			
D	IPCC default	**CS**	Country Specific
T1	IPCC Tier 1	**CR**	CORINAIR
T1a, T1b, T1c	IPCC Tier 1a, Tier 1b and Tier 1c, respectively	**RA**	Reference Approach
T2	IPCC Tier 2	**OTH**	Other
T3	IPCC Tier 3	**M**	Model

Notation keys to specify the emission factor used	
D	IPCC default
CS	Country specific
PS	Plant specific
OTH	Other
M	Model

Notation keys to specify the activity data used			
Q	Specific Questionnaire	**PS**	Plant specific
NSIA /CSO	National Statistics and Information Authority (NSIA)	**EJ**	Expert Judgement
ALCS	Afghanistan Living Condition survey (ALCS)		
UNSD	United Nations Statistics Division (UNSD)		
FAO	FAO Statistics Division (FAOSTAT)		

1.5 Brief description of key categories

The identification of key categories (KCA) is prepared in accordance with 2006 IPCC Guidelines[36]. It stipulates that a key category is one that is prioritized within the National 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 or removals, the trend in emissions or removals, or both.

Key categories according to the following equation are those that, when summed together in descending order of magnitude, add up to 95% of the sum of all Lx,t or any category meeting the 95% threshold in any year of the Level Assessment (LA) or in the Trend Assessment (TA) is considered a *key category*.

The identification of key categories consists in general of six steps. However, for the current submission a KCA no qualitative considerations were included.

- Identifying categories
- Level Assessment excluding LULUCF (Approach 1)
- Trend Assessment excluding LULUCF (Approach 1)
- Level Assessment including LULUCF (Approach 1)
- Trend Assessment including LULUCF (Approach 1)
- Qualitative considerations

1.5.1 Level of disaggregation and identification of key categories

Following *good practice* in determining the appropriate level of disaggregation of categories to identify key categories:

• The analysis is performed at the level of IPCC categories/subcategories at which the IPCC methods	✓
• Each greenhouse gas emitted from each category is considered separately.	✓
• An analysis should be performed for emissions and removals separately within a given category.	Not applicable for this submission

1.5.2 Level Assessment

The 2006 IPCC Guidelines Tier 1 approach has been applied: contribution of each source or sink category to the total national inventory.

Equation 4.1: Level Assessment (2006 IPCC GL, Vol. 1, Chap. 4.3.1)

$$\boldsymbol{Key\ category\ level\ assessment} = \frac{|\boldsymbol{source\ or\ sink\ category\ estimate}|}{|\boldsymbol{total\ contribution}|} \Rightarrow \boldsymbol{L_{x,t}} = \frac{|\boldsymbol{E_{x,t}}|}{\sum|\boldsymbol{E_{y,t}}|}$$

Where:

Lx,t = level assessment for source or sink x in latest inventory year (year t)

|Ex,t| = absolute value of emission or removal estimate of source or sink category x in year t

$\sum|\boldsymbol{E_{y,t}}|$ = total contribution, which is the sum of the absolute values of emissions and removals in year t calculated using the aggregation level chosen by the country for key category analysis. Because both emissions and removals are entered with positive sign, the total contribution/level can be larger than a country's total emissions less removals

[36] IPCC. (2006). *Methodological Choice and Identification of Key Categories. Volume 1 - General Guidance and Reporting, Chapter 4.*

1.5.3 Trend Assessment

The 2006 IPCC Guidelines Tier 1 approach has been applied:

- The trend assessment identifies categories whose trend is different from the trend of the total inventory, regardless whether category trend is increasing or decreasing, or is a sink or source.
- Categories whose trend diverges most from the total trend should be identified as **key**, when this difference is weighted by the level of emissions or removals of the category in the base year.

Equation 4.2: Trend assessment (2006 IPCC GL, Vol. 1, Chap. 4.3.1)

$$\boldsymbol{Key\ category\ Trend\ assessment} = \quad \boldsymbol{T_{x,0}} = \frac{|E_{x,0}|}{\sum_y |E_{y,0}|} \times \left| \left[\frac{(E_{x,t} - E_{x,0})}{|E_{x,0}|} \right] - \frac{(\sum_y E_{y,t} - \sum_y E_{y,0})}{\sum_y |E_{y,0}|} \right|$$

Category Significance | Category Trend | Overall Trend

Where:

$T_{x,0}$	= trend assessment of source or sink category x in year t as compared to the base year (year 0)
$\lvert E_{x,0} \rvert$	= absolute value of emission or removal estimate of source or sink category x in year 0
$E_{x,t}$ and $E_{x,0}$	= real values of estimates of source or sink category x in years t and 0, respectively
$\sum_y E_{y,t}$, and $\sum_y E_{y,0}$	= total inventory estimates in years *t* and 0, respectively

1.5.4 Results of the Key Categories Analysis (KCA)

The key categories (without LULUCF) comprise 39,628 Gg CO_2eq in the year 2017, which corresponds to 95.4% of Afghanistan's total greenhouse gas emissions. For the year 2017, by level assessment 24 key categories and by trend assessment 21 key categories were identified.

The key category with the highest contribution (1st rank) to the total national GHG emissions (excluding LULUCF) in 2017 is '3.A.1.a Enteric Fermentation – Cattle' (CH_4) which accounts for 17.8% of the total emission. This category is also the most important category in terms of emission trends: Since 1990 GHG emissions from this category have been increased by 233%.

The second most important source of GHG emissions (2nd rank) in Afghanistan is '1.A.3.b Road Transportation – Heavy-duty trucks and buses - diesel oil' (CO_2), which shares 15.5% of the total national GHG emission in 2017. This category is also an important category in terms of emission trends: Since 1990 GHG emissions from this category have also been increased by 177%.

The third most important source of GHG emissions (3rd rank) in Afghanistan is '1.A.2.m Manufacturing Industries and Construction - Others' (CO_2), with a contribution to total national emissions of 11.3% in 2017. In Manufacturing Industries and Construction - Others all fuel combustion activities are aggregated except chemical industries.

The following tables provides the results of the KCA Tier 1 approach for both level assessments and trend assessment for the years 1990 and 2017. Furthermore, key categories identified including their ranking in the level and trend assessments.

1.5.4.1 Results of the Key Categories Analysis (KCA) Tier 1 Approach – Level Assessment - 1990

The key categories (LA) identified for 1990 are listed in the following table. The key categories without LULUCF comprise 17,242 Gg CO_2e in 1990, which is a share of 95.2% of Afghanistan's total GHG emissions, excluding LULUCF.

Table 9 Results of the Key Categories Analysis (KCA) Tier 1 Approach – Level Assessment for 1990

IPCC Code	IPCC Category	GHG	1990 GHG emissions	Level Assessment	Cumulative Total
			Gg CO_2 eq		
3.D.a	Direct N_2O emissions from managed soils	N_2O	2,383	13.2%	13.2%
1.A.3.b.iii	Heavy-duty trucks and buses	CO_2	2,333	12.9%	26.0%
3.A.1.a	Cattle	CH_4	2,220	12.3%	38.3%
3.A.1.c	Sheep	CH_4	1,771	9.8%	48.1%
3.C	Rice Cultivation	CH_4	1,623	9.0%	57.0%
3.B.2.a	Cattle	CH_4	1,257	6.9%	64.0%
1.A.3.b.i	Cars	CO_2	1,120	6.2%	70.2%
5.D	Wastewater Treatment and Discharge	CH_4	675	3.7%	73.9%
3.D.b	Indirect N_2O Emissions from managed soils	N_2O	638	3.5%	77.4%
3.B.2.c	Sheep	CH_4	531	2.9%	80.3%
1.A.2.m	Other(1.A.2.m)	CO_2	428	2.4%	82.7%
3.A.1.d	Goats	CH_4	419	2.3%	85.0%
1.A.3.a.ii	Domestic Aviation	CO_2	397	2.2%	87.2%
3.A.1.e	Camels	CH_4	247	1.4%	88.6%
1.A.2.c	Chemicals	CO_2	243	1.3%	89.9%
1.A.4.b	Residential	CH_4	195	1.1%	91.0%
2.B.1	Ammonia Production	CO_2	169	0.9%	91.9%
3.A.1.f	Horses	CH_4	163	0.9%	92.8%
3.A.1.g	Mules and Asses	CH_4	157	0.9%	93.7%
1.A.3.b.iv	Motorcycles	CO_2	142	0.8%	94.5%
5.A	Solid Waste Disposal	CH_4	132	0.7%	95.2%

1.5.4.2 Results of the Key Categories Analysis (KCA) Tier 1 Approach – Level Assessment - 2017

The key categories (LA) identified for 2017 are listed in the following table. The key categories without LULUCF comprise 39,551 Gg CO_2e in 2017, which is a share of 95.2% of Afghanistan's total GHG emissions, excluding LULUCF.

Table 10 Results of the Key Categories Analysis (KCA) Tier 1 Approach – Level Assessment for 2017

IPCC Code	IPCC Category	GHG	2017 GHG emissions	Level Assessment	Cumulative Total
			Gg CO_2- eq		
3.A.1.a	Cattle	CH_4	7,385	17.8%	17.8%
1.A.3.b.iii	Heavy-duty trucks and buses	CO_2	6,452	15.5%	33.3%
1.A.2.m	Other(1.A.2.m)	CO_2	5,005	12.0%	45.4%
1.A.3.b.i	Cars	CO_2	4,707	11.3%	56.7%
3.D.a	Direct N_2O emissions from managed soils	N_2O	4,700	11.3%	68.0%
3.C	Rice Cultivation	CH_4	2,041	4.9%	72.9%
3.A.1.c	Sheep	CH_4	1,658	4.0%	76.9%
3.B.2.a	Cattle	CH_4	1,473	3.5%	80.4%
3.D.b	Indirect N_2O Emissions from managed soils	N_2O	1,212	2.9%	83.4%
5.D	Wastewater Treatment and Discharge	CH_4	998	2.4%	85.8%
3.A.1.d	Goats	CH_4	575	1.4%	87.1%
3.B.2.c	Sheep	CH_4	497	1.2%	88.3%
1.A.3.b.iv	Motorcycles	CO_2	491	1.2%	89.5%
3.A.1.g	Mules and Asses	CH_4	374	0.9%	90.4%
1.A.4.b	Residential	CH_4	303	0.7%	91.2%
1.A.1.c	Manufacture of Solid Fuels and Other Energy Industries	CH_4	264	0.6%	91.8%
1.A.3.b.ii	Light-duty trucks	CO_2	256	0.6%	92.4%
5.A	Solid Waste Disposal	CH_4	197	0.5%	92.9%
1.A.2.c	Chemicals	CO_2	197	0.5%	93.4%
3.A.1.e	Camels	CH_4	196	0.5%	93.8%
1.A.3.a.ii	Domestic Aviation	CO_2	178	0.4%	94.3%
5.D	Wastewater Treatment and Discharge	N_2O	172	0.4%	94.7%
2.B.1	Ammonia Production	CO_2	119	0.3%	95.0%
1.A.3.b.iii	Heavy-duty trucks and buses	N_2O	101	0.2%	95.2%

1.5.4.3 Results of the Key Categories Analysis (KCA) Tier 1 Approach – Trend Assessment

The key categories (LA) identified for 2017 are listed in the following table. The key categories without LULUCF comprise 39,551 Gg CO_2e in 2017, which is a share of 95.3% of Afghanistan's total GHG emissions, excluding LULUCF.

Table 11 Results of the Key Categories Analysis (KCA) Tier 1 Approach – Trend Assessment for 2017

IPCC Category Code	IPCC Category	GHG	1990 GHG emissions	2017 GHG emissions	Trend Assessment	% Contribution to Trend	Cumulative Total
			Gg CO_2 equivalent				
3.A.1.a	Cattle	CH_4	2,220	7,385	0.086	18.7%	18.7%
1.A.3.b.iii	Heavy-duty trucks and buses	CO_2	2,333	6,452	0.082	18.0%	36.7%
3.D.a	Direct N_2O emissions from managed soils	N_2O	2,383	4,700	0.060	13.0%	49.7%
1.A.3.b.i	Cars	CO_2	1,120	4,707	0.047	10.3%	60.0%
1.A.3.a.ii	Domestic Aviation	CO_2	397	178	0.027	6.0%	66.0%
1.A.2.m	Other (1.A.2.m)	CO_2	428	5,005	0.022	4.8%	70.8%
3.C	Rice Cultivation	CH_4	1,623	2,041	0.018	4.0%	74.8%
3.D.b	Indirect N_2O Emissions from managed soils	N_2O	638	1,212	0.015	3.4%	78.1%
5.D	Wastewater Treatment and Discharge	CH_4	675	998	0.013	2.8%	80.9%
3.A.1.f	Horses	CH_4	163	77	0.010	2.2%	83.1%
3.B.2.a	Cattle	CH_4	1,257	1,473	0.010	2.2%	85.4%
3.A.1.c	Sheep	CH_4	1,771	1,658	0.007	1.5%	86.8%
3.A.1.d	Goats	CH_4	419	575	0.006	1.4%	88.2%
1.A.3.b.iv	Motorcycles	CO_2	142	491	0.006	1.2%	89.4%
1.A.2.c	Chemicals	CO_2	243	197	0.005	1.1%	90.6%
3.A.1.g	Mules and Asses	CH_4	157	374	0.005	1.1%	91.7%
1.A.4.b	Residential	CH_4	195	303	0.004	0.8%	92.5%
3.A.1.e	Camels	CH_4	247	196	0.004	0.8%	93.3%
1.A.3.b.ii	Light-duty trucks	CO_2	122	256	0.004	0.8%	94.1%
5.A	Solid Waste Disposal	CH_4	132	197	0.003	0.6%	94.7%
2.B.1	Ammonia Production	CO_2	169	119	0.003	0.6%	95.3%

Table 12 Results of the Key Categories Analysis Tier 1 Approach – Trend and Level Assessment

IPCC Category Code	IPCC Category	GHG	Rank			GHG emissions [Gg CO_2-equivalent]		Share in 2017
			Level Assessment		Trend Assessment 1990-2017			
			1990	2017		1990	2017	
1.A.1.c	Manufacture of Solid Fuels and Other Energy Industries	CH_4		16		29	264	0.6%
1.A.2.c	Chemicals	CO_2	15	19	15	243	197	0.5%
1.A.2.m	Other	CO_2	11	3	6	428	5,005	12.0%
1.A.3.a.ii	Domestic Aviation	CO_2	13	21	5	397	178	0.4%
1.A.3.b.i	Cars	CO_2	7	4	4	1,120	4,707	11.3%
1.A.3.b.ii	Light-duty trucks	CO_2		17	19	122	256	0.6%
1.A.3.b.iii	Heavy-duty trucks and buses	CO_2	2	2	2	2,333	6,452	15.5%
1.A.3.b.iii	Heavy-duty trucks and buses	N_2O		24		37	101	0.2%
1.A.3.b.iv	Motorcycles	CO_2	20	13	14	142	491	1.2%
1.A.4.b	Residential	CH_4	16	15	17	195	303	0.7%
2.B.1	Ammonia Production	CO_2	17	23	21	169	119	0.3%
3.A.1.a	Cattle	CH_4	3	1	1	2,220	7,385	17.8%
3.A.1.c	Sheep	CH_4	4	7	12	1,771	1,658	4.0%
3.A.1.d	Goats	CH_4	12	11	13	419	575	1.4%
3.A.1.e	Camels	CH_4	14	20	18	247	196	0.5%
3.A.1.f	Horses	CH_4	18		10	163	77	0.2%
3.A.1.g	Mules and Asses	CH_4	19	14	16	157	374	0.9%
3.B.2.a	Cattle	CH_4	6	8	11	1,257	1,473	3.5%
3.B.2.c	Sheep	CH_4	10	12		531	497	1.2%
3.C	Rice Cultivation	CH_4	5	6	7	1,623	2,041	4.9%
3.D.a	Direct N_2O emissions from managed soils	N_2O	1	5	3	2,383	4,700	11.3%
3.D.b	Indirect N_2O Emissions from managed soils	N_2O	9	9	8	638	1,212	2.9%
5.A	Solid Waste Disposal	CH_4	21	18	20	132	197	0.5%
5.D	Wastewater Treatment and Discharge	CH_4	8	10	9	675	998	2.4%
5.D	Wastewater Treatment and Discharge	N_2O		22		97	172	0.4%
TOTAL								95.4%

1.6 Information on the QA/QC plan including verification and treatment of confidentiality issues

The 2006 IPCC Guidelines set out the major elements of a QA/QC system to be implemented by inventory compilers

(1) inventory agency responsible for coordinating QA/QC activities and definition of roles and responsibilities,
(2) a QA/QC plan,
(3) general QC procedures (Tier 1) and source category-specific QC procedures (Tier 2)
(4) QA and review procedures, and verification activities,
(5) QA/QC system interaction with uncertainty analysis (see chapter on uncertainties),
(6) reporting, documentation and archiving.

The first steps to carry out **quality assurance (QA) and quality control (QC) procedures** have already been undertaken but need further improvement. The current status and planned improvements are described in the following sub-sections.

1.6.1 Inventory agency responsible for coordinating QA/QC activities[37]

The **overall responsibility** for the **establishment and existence of a QA/QC plan**, in order to prepare the national inventory of greenhouse gases, is with National Environmental Protection Agency (NEPA).

The **QA/QC coordinator** is designated as described in Chapter 1.2.1.2.1 by the National Environmental Protection Agency (NEPA). The *QA/QC coordinator* is responsible for the following tasks:

a. to establish and maintain an inventory quality assurance/quality control (QA/QC) plan;	
b. to review and improve an inventory quality assurance/quality control (QA/QC) plan;	
c. to support and monitor the implementation of the quality policy and quality objectives	
d. to promote of quality awareness and making sure that the importance of complying with legal and official requirements is generally understood	
e. to organize and conduct - in close collaboration with the *Focal point GHG inventory* – internal audits (e.g. by NCCC);	
f. to assist the *Focal point GHG inventory* in the organization of external audits (e.g. ICA);	
g. to raise the sector experts' quality awareness and support *sector experts* in their work related to QA/QC and verification;	
h. to provide internal trainings on QA/QC and verification activities;	
i. to establish a list containing all the recommendations made during the audits, and establish a list of priorities;	
j. to establish and maintain an inventory improvement plan - in collaboration with the *Focal point GHG inventory*, and ensure its appropriate implementation of the improvements;	

[37] This role and relevant responsibilities need to be approved.

k. to provide the *National Entity* with information regarding (i) management and status of the GHG inventory and (ii) potentials and needs to improve the GHG inventory	
l. to report to the *National Entity* any problems that **may** affect the well-functioning of the MRV for Climate Change Mitigation of Afghanistan with regards to the GHG inventory.	

		In place.		*Partly in place.*		*Not in place.*

The *QA/QC coordinators and the Focal point GHG inventory* **shall** regularly exchange information on upcoming tasks, schedule, planned resources and any problems that may affect the well-functioning of the MRV of GHG Inventory of Afghanistan.

1.6.2 QA/QC plan

As described in the 2006 IPCC Guidelines, Chapter 6.5, a **QA/QC plan** is a **fundamental element of a QA/QC and verification system**. The QA/QC plan

- outlines the QA/QC and verification activities;
- include a scheduled time frame for the QA/QC activities;
- is an internal document to organize and implement QA/QC and verification activities that ensure the inventory is fit for purpose and allow for improvement.
    - QC activities
    - procedures for country specific methodologies
    - internal/external audits (QM specific)
    - inventory improvement plan
    - documentation and archiving
    - treatment of confidential data

1.6.2.1 Quality objectives

A **key component** of a QA/QC plan is the list of data **quality objectives**, against which an inventory can be measured in a review. However, a *good practice* approach is a pragmatic means of building inventories that are TACCC – and maintaining them in a manner that improves inventory quality over time. This means that the *good practice* approach reflects the national circumstances regarding financial and technical resources and capacities.

However, the GHG inventory - estimation of GHG emissions and removals including reporting elements - is subject to continuous improvement.

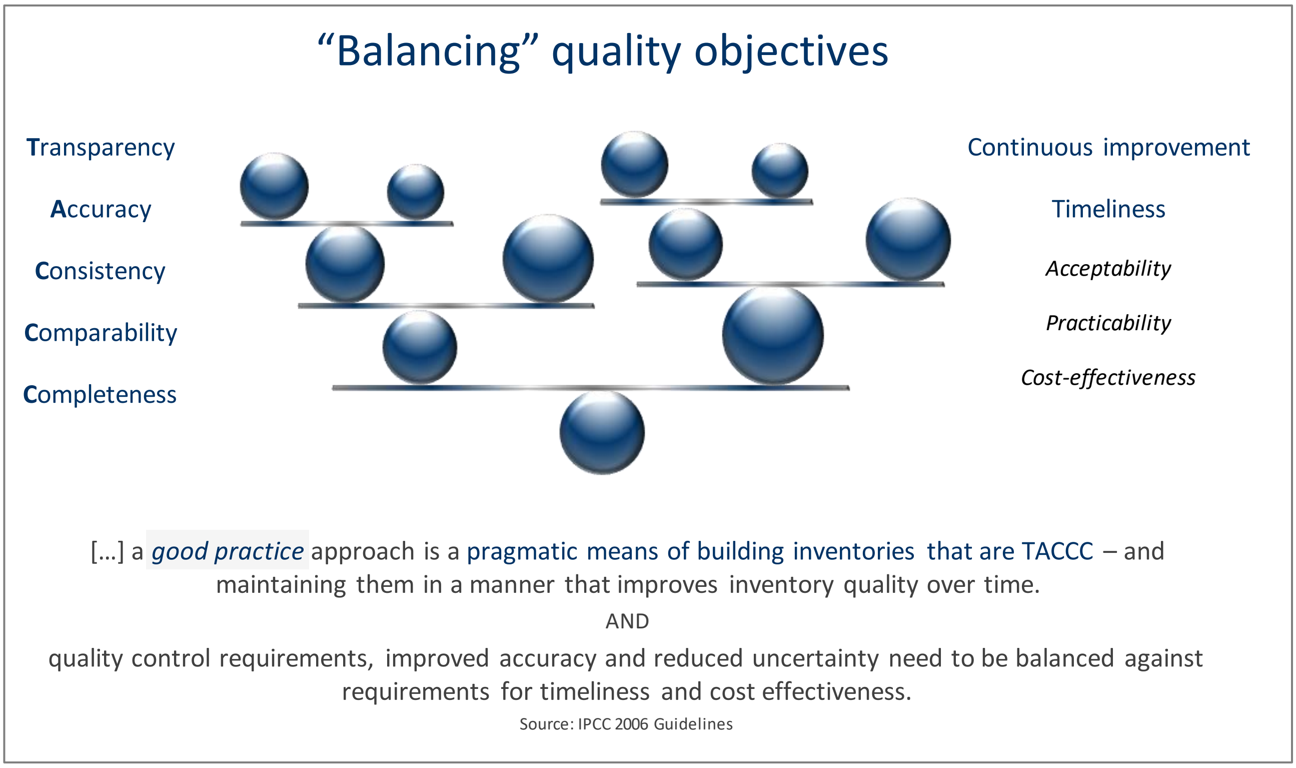

Figure 11 Balancing quality objectives

1.6.2.2 Inventory improvement plan

The planning of the GHG inventory preparation of each inventory cycle start with thoroughly analysis of the **QA/QC plan** and **Inventory improvement plan** in order to prioritize the tasks and available resources.

- QA/QC plan: bases on findings of internal and external audits; it also includes a training plan for sector experts;
- Inventory improvement plan: bases on findings of the International Consultation and Analysis (ICA), (peer-) reviews, audits of the GHG inventory.

The QA/QC plan and the improvement of the GHG inventory follows a Plan-Do-Check-Act-Cycle (PDCA-cycle)[38], which is an accepted model for pursuing a continual improvement of a process, product or service according to international standards and is in line with in the General Guidance and Reporting of the 2006 IPCC Guidelines.

Together, the BUR & NC coordinator, the Focal point GHG inventory, the National Inventory Compiler (NIC) and QA/QC Coordinator prioritize the recommended improvements (including a timeline and responsibilities) and cares for associated resources.

[38] https://asq.org/quality-resources/pdca-cycle

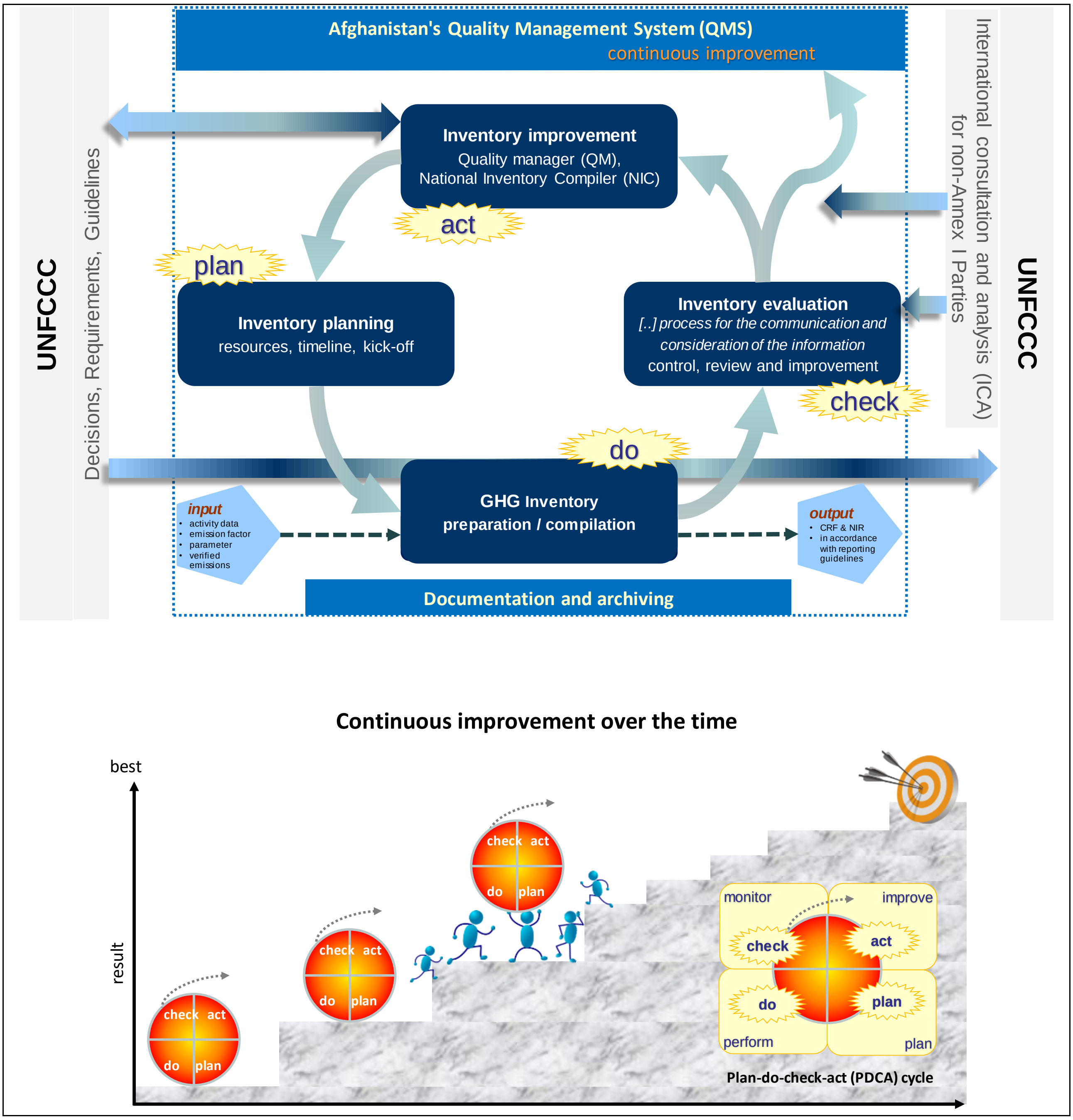

Figure 12 Continuous improvement

The results from internal/external audits, expert peer reviews and UNFCCC international consultation and analysis (ICA) are merged in the inventory improvement plan and Quality improvement plan. These plans list the relevant sector, recommendations for improvement (reference and citation), priorities, responsibilities, deadlines and confirmation of implementation.

The following table presents the template of the inventory improvement plan which is prepared for each sector, QA/QC plan and Institutional arrangements.

Table 13 Template of the inventory improvement plan

Area covered (example IPCC 2 IPPU, or QMS or INVENTORY general)											
Name of sector expert / responsible person for the relevant activity (e.g.quality manger)!											
No	IPCC category	Source	Citation	Issue	Urgency	Ressources	Timeline	responsible person (s)	Finished	Check NIC	Improvement made
1											
2											

Original quote of the (review) reports!

summary (in non-technical /informal language) **of PROBLEM and MEASURE**

Text for NIR!

Review / Technical analysis: Desk Review (DR) / Centralized Review (CR) / In Country Review (ICR), year, paragraph and/or page: e.g. "UNFCCC CR 2001, §34 Facilitative Sharing of Views (FSV) workshop under International Consultation and Analysis (ICA), round 1,2,..., year, paragraph and/or page; e.g. FSVR.1 ICA 2016, year, § 10
Archive: email, mail, (oral) complaints documented expl. with protocol "Pxxx"
Inventory team / Personal: "Name, date"
Audit protocol: "Audit_No"

!!! Each finding, which is not identified by responsible inventory person, have to be available in writen form!!!

1 - urgent / high e.g. finding were several times topic or recommendation; SHALL requirements
2 - important / medium new topic, might be urgent topic in the future, Key Category (KCA) related, SHOULD requirement
3 - low for non-urgent topics, Non-Key Category related; ENCOURAGEMENT --> does not need a schedule

Estimates of time frame for NEPA and UNFCCC focal point!
NEPA: more financial resouces are needed for research
UNFCCC Focal point: more resouces are neededs is needed
GHG inventory 20XX: can be solved within the 'normal' framework of inventory preparation (ususal planning run)

- GHG inventory 20XX if related to numbers
- NIR 20XX if related to transparency
!! In case of delay: crossing out of date (Format Cells box, under Effects, click Strikethrough) and adding new time line. Add comment with reason of delay!!!

name of responsible experts/persons (and name of institutions)

- GHG inventory 20XX if related to numbers
- NIR 20XX if related to transparency
!!!Remarks or links (e.g. NIR 2019, page 213) as a comment!!!

1.6.2.3 Inventory development cycle and guidance

The biennial and/or annual preparation of the GHG inventory follows in general the **inventory development cycle** presented in the following figure and described in Chapter 1 *Introduction to the 2006 Guidelines* of Volume 1: General Guidance and Reporting (GGR).

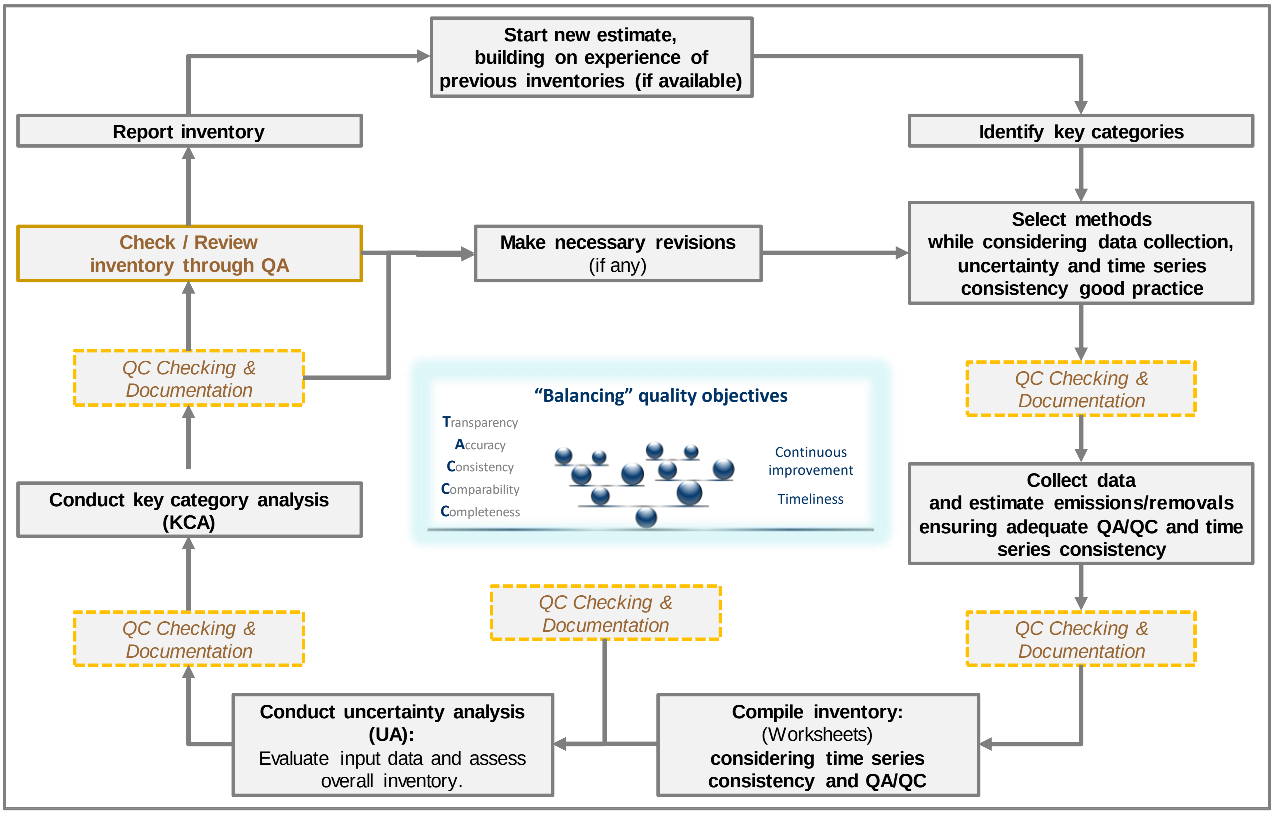

Figure 13 Inventory development cycle

Source: 2006 IPCC guidelines, Vol. 1: General Guidance and Reporting, Chap. 1: Introduction to the 2006 Guidelines, sub-chap. 1.5 Compiling an inventory, Figure 1.1, p. 1.9.

The preparation of the inventory starts always with identification of the key categories of the previous inventory followed by the selection of the appropriate identify the appropriate method for estimation for each category according to the **decision tree** of each source presented in Volume 2 – 5 of the 2006 IPCC guidelines.

The collection of activity data and relevant parameters and the estimation of emission by sources and removals by sinks should be follow the selection of the appropriate methods. As stated in the 2006 IPCC Guidelines the data collection activities should consider time series consistency and establish and maintain good verification, documentation and checking procedures (QA/QC) to minimize errors and inconsistencies in the inventory estimates.[39] Information and data on uncertainties should if possible be collected at the same time. The relevant QC Checking and documentation is done according to the QC TIER 1 & 2 Checklist which is presented in Chapter 1.6.3 (Table 15- Table 27).

The following table presents relevant inventory tasks which are based on each other. It is also indicated which documents (chapter and/or sheet) are required for the respective work steps. The relevant responsible experts involved in each step are also identified.

[39] 2006 IPCC guidelines, Vol. 1: General Guidance and Reporting, Chap. 1: Introduction to the 2006 Guidelines, 1.5 Compiling an inventory, p. 1.9.

Table 14 National Inventory preparation schedule / guidance

	When	Task	Where / What	BUR & NC coordinator	Focal point GHG inventory	National Inventory Compiler (NIC)	QA/QC coordinator	NIR coordinator	Documentation & Archiving Lead	KCA & UA coordinator	Sector experts	Data provider	QA experts	tbd
1.		Start new estimate, building on experience of previous inventories												
2.		Meeting of BUR & NC coordinator, Focal point GHG inventory, National Inventory Compiler (NIC) and QA/QC Coordinator: • Analyzing the QA/QC plan & Inventory improvement plan • Prioritizing the recommended improvements (including a timeline and responsibilities) • planning relevant resources.	Protocol (template) Inventory improvement plan.xlsx QA-QC improvement plan.xlsx											
3.		Kick-off meeting – GHG inventory team (News, deadlines, changes, etc.)	Protocol (template) Inventory improvement plan.xlsx QA-QC improvement plan.xlsx											
4.		Conducting Capacity trainings and/or refreshing general issues, sector-specific topics, QC activities	Training plan Inventory improvement plan											
5.		Identify key categories	NIR 2019 chapter 1.5.docx AFG_KCA_2019.xlsx											
6.		Select methods while considering data collection, uncertainty and time series consistency good practice	2006 IPCC GL, Volume 2 – 5 NIR – sectoral chapters											
7.		QC Checking & Documentation, updating Inventory improvement plan	AFG_Inventory improvement plan.xlsx QC checks according to part 1 of QC TIER 1 & 2 Checklist											
8.		Kick-off meeting – with data provider (with all / in groups)	Protocol (template)											
9.		Collection of activity data and relevant parameters ensuring adequate • QC Checking (completeness, transparency, accuracy) • time series consistency • documentation (if discrepancies, delay, etc.)	Data collection using data collection files (template) (source-specific) from data provider											
10.			Archiving response (letter, Email, etc.) in folder 04_Archive											
11.		Preparation/Updating of calculation sheets • adding new year • modification if higher TIER methodology will be applied • updating NIR tables templates • updating graphs	source-specific calculation sheets, e.g. 1A1a_InventoryTool_AFG.xlsx											

	When	Task	Where / What	BUR & NC coordinator	Focal point GHG inventory	National Inventory Compiler (NIC)	QA/QC coordinator	NIR coordinator	Documentation & Archiving Lead	KCA & UA coordinator	Sector experts	Data provider	QA experts	tbd
12.		Estimate emissions/removals ensuring adequate QA/QC and time series consistency	Inserting activity data or linking data collection files with calculation files											
13.		QC Checking & Documentation, updating Inventory improvement plan	• Documentation in column Update of each "source-specific" calculation file, sheet AD • QC checks according to part 1,2,3 and 6 of QC TIER 1 & 2 Checklist											
14.		Preparation/Updating of Inventory file • adding new year • adding new calculation file, if needed • updating NIR tables templates • updating graphs	CTR-CommonReportingTables_AFG.xlsx											
15.		Compile inventory considering time series consistency and QA/QC: update links of all calculation sheets	CTR-CommonReportingTables_AFG.xlsx QC checks according to part 2b of *QC TIER 1 & 2 Checklist*											
16.		Sharing results with inventory team and QC check of Inventory file by sector experts and if needed revision of Inventory file	QC checks according to part 1, 2 and 3 of *QC TIER 1 & 2 Checklist*											
17.		Make necessary revisions (if any)												
18.		Conduct uncertainty analysis (UA): Evaluation of input data: AD and EF.	"source-specific" calculation files, sheet uncertainties											
19.		Conduct uncertainty analysis (UA): assessment of overall inventory uncertainty.	AFG_Uncertainties_Table6.1.xlsx QC checks according to part 4 and 5 of *QC TIER 1 & 2 Checklist*											
20.		QC Checking & Documentation, updating Inventory improvement plan	QC checks according to part 7 of *QC TIER 1 & 2 Checklist*											
21.		Sharing results with inventory team and QC check of UA file by sector experts and NIR coordinator												
22.		Make necessary revisions (if any)												
23.		Conduct key category analysis (KCA) • Update formula for new inventory year • Update link with CTR-CommonReportingTables_AFG.xlsx	AFG-KCA-2019.xlsx CTR-CommonReportingTables_AFG.xlsx											
24.		QC Checking & Documentation, updating Inventory improvement plan	QC checks according to part 1 of *QC TIER 1 & 2 Checklist*											

	When	Task	Where / What	BUR & NC coordinator	Focal point GHG inventory	National Inventory Compiler (NIC)	QA/QC coordinator	NIR coordinator	Documentation & Archiving Lead	KCA & UA coordinator	Sector experts	Data provider	QA experts	tbd
25.		Sharing results with inventory team and QC check of KCA file by sector experts and NIR coordinator	AFG-KCA-2019.xlsx											
26.		Make necessary revisions of emission estimation if higher TIER methodology has to be applied according to decision tree of relevant source (if any)												
27.		Repeat step 14. to – 25. in case of revision												
28.		• Add new in IPCC software • Update of timeseries entry files for IPCC software • Update database (sector)												
29.		QC Checking & Documentation, updating Inventory improvement plan	QC checks according to part 2 and 3 of *QC TIER 1 & 2 Checklist*											
30.		Compile inventory with IPCC software as QC activity												
31.		QC Checking & Documentation, updating Inventory improvement plan	QC checks according to part 2 and 3 of *QC TIER 1 & 2 Checklist*											
32.		Update NIR sectoral chapter												
33.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 2 and 3 of *QC TIER 1 & 2 Checklist*											
34.		Update NIR chapter 1 Introduction												
35.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 2 and 3 of *QC TIER 1 & 2 Checklist*											
36.		Update NIR chapter 1.6 KCA												
37.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 2 and 3 of *QC TIER 1 & 2 Checklist*											
38.		Update NIR chapter 1.7 Uncertainties												
39.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 2 and 3 of *QC TIER 4 & 5 Checklist*											

	When	Task	Where / What	BUR & NC coordinator	Focal point GHG inventory	National Inventory Compiler (NIC)	QA/QC coordinator	NIR coordinator	Documentation & Archiving Lead	KCA & UA coordinator	Sector experts	Data provider	QA experts	tbd
40.		Finalization of Inventory Improvement Plan and QA-QC improvement plan Finalization of NIR Chapter 9 Recalculation and Improvement	Inventory improvement plan.xlsx QA-QC improvement plan.xlsx											
41.		Update NIR chapter 1.6 QA/QC												
42.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 2, 3, and 7 of *QC TIER 1 & 2 Checklist*											
43.		Update NIR chapter 2 Trend												
44.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 2 of *QC TIER 1 & 2 Checklist*											
45.		Treatment of confidentiality issues	Checklist - Confidential data											
46.		Update NIR chapter # References												
47.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 7 of *QC TIER 1 & 2 Checklist*											
48.		Check / Review inventory and NIR through QA	QA checks using the *QC TIER 1 & 2 Checklist*											
49.		Make necessary revisions of emission estimation and /or NIR based on findings and recommendations of QA (if any)												
50.		Repeat step 14. to – 47. in case of revision												
51.		Finalize National GHG Inventory and National Inventory Report (NIR) for approval												
52.		Reporting of National Inventory and National Inventory Report (NIR)												
53.		Collection of QC documents, QA documents, Inventory Improvement Plan												
54.		Archiving calculations files, Inventory files, KCA & UA file, NIR, QC documents, QA documents, Inventory Improvement Plan	05_QA-QC\04_InventoryImprovementList 06_Inventory\2018\Submission 07_NIR\2018_NIR\02_Submission_UNFCCC											

1.6.3 Quality control (QC) procedures

As stated in the 2006 IPCCC Guidelines, Chapter 6.6, and presented in the following figure,

- 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.
- category-specific QC complements general inventory QC procedures and is directed at specific types of data used in the methods 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

does NOT require	requires
knowledge of the emission source category	
⇩ general	⇩ source specific
QC procedures sector experts (1st party) performed throughout preparation of inventory	
TIER 1	**TIER 2**
data validation, calculation sheet (check of formal aspects)	**preparation of NIR, comparison with IPCC Guidelines** (check of applicability, comparisons)
QA procedures quality manager (2nd or 3rd party; staff not directly involved, preferably independent) performed at different levels or after inventory work has finished	
TIER 1 basic, before submission	
	expert peer review **internal audit / expert peer review** evaluate if TIER2 QC is effectively performed (check if methodologies are applicable)
TIER 2 extensive	
(quality management) system audit evaluate if TIER 2 QC is effectively performed	**expert peer review** **International Consultation and Analysis (ICA)** • A technical analysis of BUR by a team of experts (TTE) • A facilitative sharing of views in the form of workshop under the SBI evaluate if TIER 2 QC is effectively performed (check if methodologies are applicable)

Figure 14 General overview of QA/QC procedures

QC procedures are performed as defined in the QC TIER 1 & 2 Checklist which is prepared according to IPCC 2006 Guidelines,

- Table 6.1 General inventory QC procedures
- A1. General QC checklist
- A2. Category-specific QC checklist

For each step of the inventory cycle relevant QC checks are prepared. Furthermore, the checks are divided in content checks and formal checks. As well checks could be done for activity data, emission factor, and emission factor separately. In case of higher Tier method, not only AD and EF are used but also other parameters. In case of reported AD and Emissions (e.g. Emission trading data (ETS) data or data from NAMA projects) the checks only of IEF are important.

As the estimation of the GHG emissions and removal and the preparation of the reporting elements NIR and NAI tables are done at different stages of the inventory preparation cycle, the QC TIER 1 & 2 Checklist provides guidance on how and where the checks have to be done. Finally, each source has its own QC TIER 1 & 2 Checklist which can be individually refined.

1	Choosing Good Practice method
2	Activity data / Emission factors / Emissions– check regarding content
2a	Trend checks
2b	Check time series consistency (Recalculations due to methodological changes & refinements / Adding new categories / Tracking increases & decreases due to technological change etc.)
2c	Check completeness
2d	Direct emission measurement: Checks on procedures to measure emissions
3	Activity data / Emission factors / Emissions – Formal check - There shall be no transcription errors in the calculation and each data has a clear reference?
3a	Check that assumptions and criteria for the selection of activity data are documented
3b	Check for transcription errors in data input and reference: There shall be no transcription errors in the activity data and each data has a clear reference (e.g. UNSD 2016)?
3c	Calculations correct / Check that parameters and units are correctly recorded and that appropriate conversion factors are used.
3d	Check for consistency in data between categories.
4	Uncertainties – Check regarding content
4a	Check that uncertainties in emissions and removals are estimated and calculated correctly
5	Uncertainties – Formal check - There shall be no transcription errors in the calculation and each data has a clear reference?
6	Check the integrity of database files
7	Review of internal documentation/calculation sheet and archiving.

Table 15 QC TIER 1 & 2 Checklist according to IPCC 2006 Guidelines - Chapter 6

1	**QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6**			
2	**Submission**		**Source / Sink Category**	
3	**Title of calculation sheets/internal_documentation/NIR/CTR** (e.g. AFG-2019_v2.1.xls):			
4	**Insert of data path/folder**			
5	**Source/sink category estimates prepared by (name)**			
6	**Summary of general QC checks and corrective action**			
7	**Summary of results of checks and corrective actions taken**			
8	**Suggested checks to be performed in the future**			
9	**Any residual problems after corrective actions have been taken**			
10	**Other**			
11	**Date**		**Signature**	

13	**EXPLANATION & INSTRUCTION**			*QC checks should be not seen as an additional task; QC should help you to document your QC checks which you are doing anyway*				**Abbreviation**			
14	**Why checks for each gas?** The estimations for the different GHG might be different!							TTE	Team of experts	NIR	National Inventory report
15	**What kind of remarks have to be documented and why?** Any comments, additional information, and/or corrective measures etc. should be documented; at the end of the inventory year, an analysis of the remarks will be done by the QM in order to undertake measures to prevent such findings (if possible :-).							ICA	International consultation and analysis	FSV	facilitative sharing of views
16	**What is the reason for dating the checks?** The inventory preparation process is a long and 'discontinuously' process; therefore the checklist serves also as a log / chronicle.							QA	Quality Assurance	sectoral chap	sectoral chapter
17	**What should be mentioned under Reference?** Here the exact location of the findings should be referenced!							QC	Quality Control	CTR	common reporting tables
18	**Why have checks to be done for activity data, emission factor, and emission factor separately?** In case of higher Tier method, not only AD and EF are used but also other parameters. In case of reported AD and Emissions (e.g. ETS data) the checks only of IEF are important.							ERT	Expert Review Team	NAI	Non Annex I Party
19	**AD**	**Activity data**	**internal docu**	**internal documentation**	**Y = Yes**	**NA = not applicable**	**NR = Not relevant**	**If not answered with YES, please provide all information regarding comments, corrective measures, etc.**			
20	**EF**	**Emission factor**	**calc sheet**	**calculation sheet**	**N = No**	**NC = not checked**	**NO = Not occurent**				
21	**EMI**	**Emission**	**KCA**	**key category analysis**		**C = Confidential**	**IE = Included elsewhere**				

Table 16 QC TIER 1 & 2 Checklist – (1) Choosing Good Practice method

QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NF_3	SO_2	NOx	NMVOC	NH_3	CO	Remarks Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
1 Choosing Good Practice method																			
Is a more detailed higher tier method selected for *key categories* according to the latest key category analysis (KCA)? If not, is a comprehensive and plausible explanation provided? *Any key categories where the good practice method cannot be used should have priority for future improvements.*	*calc sheets*																		
	NIR - sectoral chap																		
	NIR – chap 1.4																		
Is the methodological choice <u>in line</u> with the sectoral 'Decision Tree to choose a Good Practice method'? Is the methodological choice clearly documented?	*In line with Decision Tree*																		
	calc sheets / background documentation																		
	NIR - sectoral chap																		
Is the methodological choice in line with the Inventory Improvement plan? If not, are explanations and new schedule provided?	*calc sheets / background documentation*																		
	NIR - sectoral chap																		
Is the methodological choice applicable to the entire time series (starting from the base year)? If not, is an explanation and appropriate recalculation provided?	*time series consistent*																		
	calc sheets / background documentation																		
	NIR - sectoral chap																		
	NIR – chap 11																		

Table 17 QC TIER 1 & 2 Checklist - (2a) Check regarding content: Activity data / Emission factors / Emissions

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included		CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
38	**2 Activity data / Emission factors / Emissions– check regarding content**																				
39	**2a Trend checks**																				
40	Are the activity data applicable according to the sectoral 'Decision Tree' and sector-specific *good practice guidance* ?	*calc sheets / background documentation*																			
41		*NIR - sectoral chap*																			
42		*NIR – chap 1.4*																			
43		*NAI table - CTR*																			
44	Confirm consistency and plausibility of the trend of **activity data / emission factor / emissions**! If there are significant outlier (dips or jumps) from expected trends, has a re-check of the data been done? Are plausible explanations for any unexplained or unusual trends provided (documented)?	*documented*	*calc sheets*																		
45		*re-checked*	*calc sheets / background documentation*																		
46		*documented*																			
47		*documented*	*NIR - sectoral chap*																		
48		*documented*	*NIR - Chap 2*																		

Table 18 QC TIER 1 & 2 Checklist - (2a) Check regarding content: Activity data / Emission factors / Emissions

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included		CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Finding Y/ N/ NR	Correction Date	Person	References
1	**2a Trend checks**																				
49	Are the **activity data (AD) and other parameters** plausible in comparison to / consistent with other references? (e.g. national statistics *versus* international statistics *versus* data from association *versus* plant specific data *versus* literature)	*Compared with*																			
50		AD- Official data	*calc sheets / background documentation*																		
51		AD- Other data																			
52		EF- Official data																			
53	Are the **emission factors (EF) and other parameters** plausible in comparison to / consistent with other references? (e.g. default, national values *versus* international values (Cross country) *versus* values from associations *versus* plant specific data *versus* literature)	EF- Other data																			
54		EMI- Official data																			
55		EMI- Other data																			
56		AD- Official data	*NIR - sectoral chap*																		
57		AD- Other data																			
58	Are the **emissions (EMI)** plausible in comparison to / consistent with other references? (e.g. national estimates *versus* international estimates *versus* estimates from associations *versus* plant specific estimates *versus* literature)	EF- Official data																			
59		EF- Other data																			
60		EMI- Official data																			
61		EMI- Other data																			
62	Is information about representativeness of emission factors, national circumstances and analogous emissions data provided?	*calc sheets / background documentation*																			
63		*NIR - sectoral chap*																			
64	Are the values of implied emission/removal factors across time series checked and are explanations for unexplained outliers provided?	Check	*calc sheets*																		
65		explanation																			
66		*NIR - sectoral chap*																			
67	Is a sufficient methodology for filling in time series (overlap, interpolation, trend extrapolation, etc.) for activity , emission factor that are not available annually applied?	*calc sheets / background documentation*																			
68		*NIR - sectoral chap*																			

Table 19 QC TIER 1 & 2 Checklist - (2b) Check time series consistency

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6		Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
69	**2b Check time series consistency** (Recalculations due to methodological changes & refinements / Adding new categories / Tracking increases & decreases due to technological change etc.)																				
70	For each category: Are plausible explanations on changes in activity data/ emission factors/ emissions resulting in recalculations provided (documentation)? If there is a change in AD/EF/EMI is the temporal consistency in time series ensured? Are plausible explanations on changes resulting in recalculations provided? If no consistency can be ensured, is an explanation provided?		*No change*																		
71		AD - Changes documented	*calc sheets / background documentation*																		
72		AD -Consistency ensured																			
73		AD - Explain for inconsistency																			
74		EF - Changes documented																			
75		EF -Consistency ensured																			
76		EF - Explain for inconsistency																			
77		EMI - Changes documented																			
78		EMI -Consistency ensured																			
79		EMI - Explain for inconsistency																			
80		AD - Changes documented	*NIR - sectoral chap*																		
81		AD -Consistency ensured																			
82		AD - Explain for inconsistency																			
83		EF - Changes documented																			
84		EF -Consistency ensured																			
85		EF - Explain for inconsistency																			
86		EMI - Changes documented																			
87		EMI -Consistency ensured																			
88		EMI - Explain for inconsistency																			
89		Changes documented	*NIR - Chap 11*																		

Table 20 QC TIER 1 & 2 Checklist – (2c) Check completeness

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Finding Y/ N/ NR	Correction Date	Person	References
103	**2c Check completeness**																			
104	Confirm that activity data / emission factors / emnissions are reported for all categories and for all years from the appropriate base year to the period of the current inventory!	*AD - calc sheets / background documentation*																		
105		*AD - NIR - sectoral chap*																		
106		*EF - calc sheets / background documentation*																		
107		*EF - NIR - sectoral chap*																		
108		*EMI - calc sheets / background documentation*																		
109		*EMI - NIR - sectoral chap*																		
110	For subcategories, confirm that the entire category is being covered.	*calc sheets / background documentation*																		
111		*NIR - sectoral chap*																		
112	Is a clear definition of 'Other' type categories (Non-specified) provided?	*calc sheets / background documentation*																		
113		*NIR - sectoral chap*																		
114		NAI table - CTR																		
115	Are there known data gaps that result in incomplete estimates (notation key NE)? Are these data gaps documented, including a qualitative evaluation of the importance of the estimate in relation to total emissions (e.g., subcategories classified as 'NE')?	*No data gaps*																		
116		*calc sheets / background documentation*																		
117		*NIR - sectoral chap*																		
118		*NIR – chap 1.8 & Annex*																		
119		*NAI table - CTR*																		
120	Are all information provided in respect to the notation key IE (allocation as per IPCC Guidelines)?	*calc sheets / background documentation*																		
121		*NIR - sectoral*																		
122		*NIR – chap 1.8 & Annex 5*																		
123		*NAI table - CTR*																		
124	Are the notation key NA and NO correctly used?	*calc sheets / background documentation*																		
125		*NIR - sectoral chap*																		
126		*NAI table - CTR*																		

Table 21 QC TIER 1 & 2 Checklist – (2d) Direct emission measurement: Checks on procedures to measure emissions

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
127	**2c Check completeness**																			
127	Are there confidential data used (notation key C)? ® **see section Checklist Confidential data !!!**																			
128	Have uncertainties for activity data been estimated and documented? ® **see section Uncertainty below!!!**																			
129	Do the activity / emission factors data relying on a legal reporting commitment (Stockholm convention, questionnaire of UN statistic devision (UNSD), International Energy Agency (IEA) questionnaire, etc.)?	*calc sheets / background documentation*																		
130		*NIR - sectoral chap*																		
131		*NIR - chap 1.4*																		
132	For site-specific activity data, are any national or international standards applicable to the measurement of the data? If so, have they been employed and documented?	*calc sheets / background documentation*																		
133		*NIR - sectoral chap*																		
134	**2d Direct emission measurement: Checks on procedures to measure emissions**																			
135	Which variables rely on direct emission measurements?	*calc sheets / background documentation*																		
136		*NIR - sectoral chap*																		
137	Are procedures used to measure emissions, including sampling procedures, equipment calibration and maintenance? Are these procedures documented?	*calc sheets / background documentation*																		
138		*NIR - sectoral chap*																		
139	Have standard procedures been used, where they exist (such as IPCC methods or ISO standards)?	*calc sheets / background documentation*																		
140		*NIR - sectoral chap*																		

Table 22 QC TIER 1 & 2 Checklist – (3a) Formal check: Activity data / Emission factors / Emissions

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done: Date	Finding Y/ N/ NR	Correction: Date	Person	References
141	**3 Activity data / Emission factors / Emissions – Formal check** - There shall be no transcription errors in the calculation and each data has a clear reference ?																			
142	Is the collection of activity data, emission factor, emissions transparent (described)?	*calc sheets / background documentation*																		
143		*NIR*																		
144	**3a Check that assumptions and criteria for the selection of activity data are documented**																			
145	Are assumptions and criteria for the selection of activity data, emission factor, emissions (e.g. PS) and other relevant parameters documented?	*calc sheets / background documentation*																		
146		*NIR*																		
147	Cross-check descriptions of activity data, emission factor, emissions and other input data with information on categories and ensure that these are properly recorded and archived.	*calc sheets / background documentation*																		
148		*NIR*																		
149		*Archive*																		

Table 23 QC TIER 1 & 2 Checklist – (3b) Check for transcription errors in data input and reference

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done: Date	Check done: Finding Y/ N/ NR	Correction: Date	Correction: Person	References
150	**3b Check for transcription errors in data input and reference:** *There shall be no transcription errors in the activity data and each data has a clear reference (e.g. UNSD 2016)?*																			
151	Are the activity data, emission factors, emissions and other input data correctly entered and transcribed? Samples in case of big data sets! Electronic data should be used where possible to minimize transcription errors!	*AD -From original source (data provider) to calculations sheet*																		
152		*AD - From calculation sheet to NAI table / CTR*																		
153		*AD - From calc sheets to NIR*																		
154		*AD - From calc sheets to uncertainty file*																		
155		*EF- From original source (data provider) to calculations sheet*																		
156		*EF - From calculation sheet to NAI table / CTR*																		
157		*EF - From calc sheets to NIR*																		
158		*EF - From calc sheets to uncertainty file*																		
159		*EMI - From original source (data provider) to calculations sheet*																		
160		*EMI - From calculation sheet to NAI table / CTR*																		
161		*EMI - From calc sheets to NIR*																		
162		*EMI - From calc sheets to uncertainty file*																		
163		*From calc sheets to 'KCA' file*																		
164	Confirm that bibliographical data references for every activity data, emission factors and other input data (primary data) are properly cited ! Confirm that bibliographical data references for every primary data - Emissions (e.g. EU ETS) are properly cited.	*From original source (data provider)*																		
165		*to calc sheets / background documentation*																		
166		*calc sheets / background documentation*																		
167		*to Model (e.g. energy/transport)*																		
168		*to NIR*																		
169	Do the citations in spreadsheets and NIR conform to acceptable style guidelines (UNFCCC reporting GL)?	*calc sheets / background documentation*																		
170		*Structure of NIR, proposed by the guidelines? (annotated NIR/Annex II: Recommended structure for the Informative Inventory Report)*																		
171	Randomly cross-check a sample of input data from each source category (either measurements or parameters used in calculations) for transcription errors																			
172																				
173	Randomly cross-check bibliographical citations for transcription errors																			
174																				
175	Randomly check that the originals of citations (including Contact Persons) contain the material & content referenced																			
176																				

Table 24 QC TIER 1 & 2 Checklist – (3c) Check calculations & Check for consistency in data between categories.

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6		Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Finding Y/ N/ NR	Correction Date	Person	References
177	**3c Calculations correct / Check that parameters and units are correctly recorded and that appropriate conversion factors are used.**																				
178	Are all calculation <u>steps</u> (intermediate results) regarding activity data, emission factor and emissions included (instead of presenting results only? Is the data transmission of intermediate result correct?	provided	*calc sheets / background documentation*																		
179		correct																			
180		provided	*NIR - sectoral chap*																		
181		correct																			
182	Are parameters presented/used appropriately in the spreadsheets and transferred accurately to the NIR & CTR?	appropriately used	*calc sheets / background documentation*																		
183		referenced																			
184		labelled																			
185		carried / go through	*NIR - sectoral chap*																		
186		transferred																			
187	Are conversion factors presented/used appropriately in the spreadsheets and transferred accurately to the NIR & CTR?	appropriately used	*calc sheets / background documentation*																		
188		referenced																			
189		carried / go through	*NIR - sectoral chap*																		
190		transferred																			
191	Are the temporal and spatial adjustments factors (conservative factors) are used correctly and documented ?	correct	*calc sheets / background documentation*																		
192		documented																			
193		correct	*NIR - sectoral chap*																		
194		documented																			
195	Are the units properly labelled and correctly carried through from beginning to end of calculations? Are the units transferred accurately to the NIR & CTR?	correct	*calc sheets / background documentation*																		
196		labelled																			
197		carried / go through																			
198		transferred	*NIR - sectoral chap*																		
199			*NAI table / CTR*																		
200	**3d Check for consistency in data between categories.**																				
201	Are parameters (e.g., activity data, constants) identified that are common to multiple categories? Confirm that there is consistency in the values used for these parameters in the emission/removal calculations?	*calc sheets & NIR of sector #*																			
202		*calc sheets & NIR of sector #*																			
203		*calc sheets & NIR of sector #*																			
204		*calc sheets & NIR of sector #*																			
205		*calc sheets & NIR of sector #*																			

Table 25 QC TIER 1 & 2 Checklist – (4) Uncertainties – Check regarding content

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
206	**4 Uncertainties – Check regarding content**																			
207	**4a Check that uncertainties in emissions and removals are estimated and calculated correctly**																			
208	Is the uncertainty estimation of activity data plausible?	*Default*																		
209		*Expert judgement*																		
210																				
211	Are the qualifications of individuals providing expert judgement for uncertainty estimates appropriate?																			
212																				
213																				
214	Is the uncertainty estimation of emission factors plausible?	*Default*																		
215		*Expert judgement*																		
216																				
217	Are the qualifications of individuals providing expert judgement for uncertainty estimates appropriate?																			
218																				

Table 26 QC TIER 1 & 2 Checklist – (5) Uncertainties – Formal check

No.	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included		CO_2	CH_4	N_2O	HFC	PFC	SF_6	NF_3	SO_2	NO_x	NMVOC	NH_3	CO	Remarks Comments, Corrective measures	Check done: Date	Check done: Finding Y/ N/ NR	Correction: Date	Correction: Person	References
219	**5 Uncertainties – Formal check** *There shall be no transcription errors in the calculation and each data has a clear reference ?*																				
220	Is the designation of uncertainties understandable?		*Sector calc sheets*																		
221			*NIR - sectoral chap*																		
222			*internal 'Uncertainty' calculation file*																		
223	Are the uncertainties estimates complete?		*Calc sheets / background documentation*																		
224			*NIR - sectoral chap*																		
225			*internal 'Uncertainty' calculation file*																		
226			*Table 6.1 GPG Uncertainty Analysis*																		
227	Are the Emissions and the Uncertainties of activity data and emission factor correctly entered and transcribed? *Electronic data should be used where possible to minimize transcription errors!*		*Sector calc sheets*																		
228			*NIR - sectoral chap*																		
229			*internal 'Uncertainty' calculation file*																		
230			*Table 6.1 GPG Uncertainty Analysis*																		
231	Confirm that bibliographical data references for each uncertainty of AD & EF are properly cited		*Calc sheets / background documentation*																		
232			*NIR - sectoral chap*																		
233			*internal 'Uncertainty' calculation file*																		
234	Are assumptions and criteria for the selection of uncertainty of activity data (AD) and emission factor (EF) concerning expert judgement documented?	qualifications	*Sector calc sheets*																		
235		assumptions																			
236		expert judgements																			
237		qualifications	*internal 'Uncertainty' calculation file*																		
238		assumptions																			
239		expert judgements																			
240		qualifications	*NIR - sectoral chap*																		
241		assumptions																			
242		expert judgements																			
243	The archiving of primary data and records has to be ensured! Are the originals of new citations (e-mails, mails, literature sources, statistics, etc.) in the archive?		*properly labelled*																		
244			*stored*																		
245			*stored*																		
246	Randomly cross-check bibliographical citations for transcription errors																				
247	Randomly cross-check: originals of citations (including Contact Reports) contain the material & content referenced																				

Table 27 QC TIER 1 & 2 Checklist – (6) Check the integrity of database files & (7) Review of internal documentation/calculation sheet and archiving.

Row	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6		Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
248	**6 Check the integrity of database files**																				
249 250	Are the data relationships and processing steps correct (e.g., equations) in the spreadsheets? Confirm the correctness of calculations (formulas)!		*calc sheets*																		
251 252	Are data path and data coherence understandable?		*calc sheets*																		
253 254	Are input data and calculated data (e.g. intra/extrapolated data) clearly differentiated in the spreadsheets?		*calc sheets*																		
255 256	Is a representative sample of calculations checked by hand or electronically (only for models and complex calculations)?		*calc sheets*																		
257 258	Is it ensued that data fields are properly labelled and have the correct design specifications?		*calc sheets*																		
259 260	Are the calculations cross-checked (tested) with “quick” calculations?		*calc sheets*																		
261 262	Is it ensured that adequate documentation of database and model structure and operation are archived.		*calc sheets*																		
263	**7 Review of internal documentation/calculation sheet and archiving.**																				
264 265	Is a detailed internal documentation to support the estimates and enable reproduction of the emission, removal and uncertainty estimates available?																				
266	Is the archiving of primary data – acticity data, other parameters and records - ensured?	properly labelled																			
267		stored																			
268	Are the originals of new citations (e-mails, mails, literature sources, statistics, etc.) in the archive and stored to facilitate detailed review?	properly labelled																			
269		stored																			
270																					
271 272	Is the archive closed and retained in secure place following completion of the inventory?																				
273 274	Is the integrity of any data archiving arrangements of outside organisations involved in inventory preparation ensured?																				

1.6.4 QA and review procedures, and verification activities

As stated in the 2006 IPCCC Guidelines, Chapter 6.8, and presented in Figure 14, Quality assurance (QA) comprises activities outside the actual inventory compilation. Good practice for QA procedures includes reviews and audits to

- assess the quality of the inventory,
- determine the conformity of the procedures taken and to identify areas where improvements could be made.

QA procedures may be taken at different levels (internal/external), and they are used in addition to the general and category-specific QC procedures

Through internal/external audit and expert peer review an evaluation if TIER2 QC is effectively performed:

- GHG inventory preparation and the GHG inventory is in line with 2006 IPCC Guidelines;
- data collection, calculation, referencing and archiving is handled according to the QA/QC plan;
- enough resources for the preparation of the GHG inventory and related reporting elements (NAI table and National Inventory Report (NIR)) are guaranteed by relevant national institutions;
- relevant activity data (e.g. energy balance, livestock data) are available and if the reliability of external data is ensured;
- QA/QC plan needs improvement;
- recommendations of UNFCCC international consultation and analysis (ICA) and previous internal/external audits and expert peer reviews have been considered and implemented;
- tailor-made / suitable trainings for the sector experts, National Inventory Compiler and other experts involved in the inventory preparation are provided.

The QC TIER 1 & 2 Checklist which is presented in Chapter 1.6.3 (Table 15- Table 27) is also used for the QA procedures.

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1.6.5 Documentation and archiving

1.6.5.1 Documentation

For each sector the documentation of the methodology and actual emission calculation (e.g. 1A2m_OtherTool_AFG.xlsx) includes:

- Description (source/sink category, emissions, key source, completeness, uncertainty),
- Methodology (decision tree).
- „Logbook" (who did what and when) (see Table 14 National Inventory preparation schedule / guidance)
- References for activity data, emission factors and/or emissions, respectively,
- Documentation of assumptions, sources of data and information, expert judgements etc. to allow full reproduction and understanding of choices made,
- Recalculations,
- Planned improvements,
- QC activities.

Table 28 ReadMe of emission calculation sheets

Sheet name	Content	Content description	Password
ChangeLog	Information regarding updating / modification / changes	*Information*	*unprotected worksheet*
worksheet_1A	Activity data for transfer to IPCC software	*Activity data*	*protected worksheet*
Decision tree	Decision tree: choice of a good practice method	*Information*	*unprotected worksheet*
1A1ai_CRT	**GHG** emissions (automatised) for CRT reporting	*(intermediate)* ***result***	*protected worksheet*
1A1ai_NFR	**Air Pollutants** emissions (automatised) for NFR	*(intermediate)* ***result***	*protected worksheet*
1A1ai_AD	**Calculation of emissions by fuel and GHG / Pollutants**	***Input data***	*unprotected worksheet but occasional protected cells*
Uncertainty	Information related to Uncertainties for transfer to Uncertainty_AFG.xlsx NIR sectoral Chapter	Uncertainty data	*unprotected worksheet*
PlannedImprovements	Information related to Planned improvements for transfer to NIR sectoral Chapter for transfer to Chapter Recalculation & Planned improvements	Planned improvements	*unprotected worksheet*
Recalculation	Information related to Recalculation for transfer to NIR sectoral Chapter for transfer to Chapter Recalculation & Planned improvements	Recalculation	*unprotected worksheet*
EF IPCC	Emission factors of 2006 IPCC GL for sector 1 A	*Emission factors*	*protected worksheet*
EF EMEP-EEA 1A1	Emission factors of EMEP/EEA GB for sector 1.A.1	*Emission factors*	*protected worksheet*
Matrix_EBxCRF	Correspondance of activities of Energy Balance (IEA/EUROSTAT Questionnaire) and CRF sub categories	*Information*	*unprotected worksheet*
DropDown&Definition	List for DropDown and Definitions of sectors and fuels	*Information*	*protected worksheet*
ExcelSuport	Excel support regarding used formulars	*Information*	*unprotected worksheet*

1.6.5.2 Expert judgements

The documentation of expert judgements in line with the IPCC 2006 Guidelines should include:

- Name of the expert and institution/department,
- Date,
- Basis of judgement (references to relevant studies etc.),
- Underlying assumptions

1.6.5.3 Archiving

Archiving takes place on a central server within the folder ‘GHG inventory’ and relevant subfolders. The structure of the ‘GHG inventory’ is provided in the next Figure. Relevant literature has to be archived and references to be stated in the internal documentation as well as in the NIR.

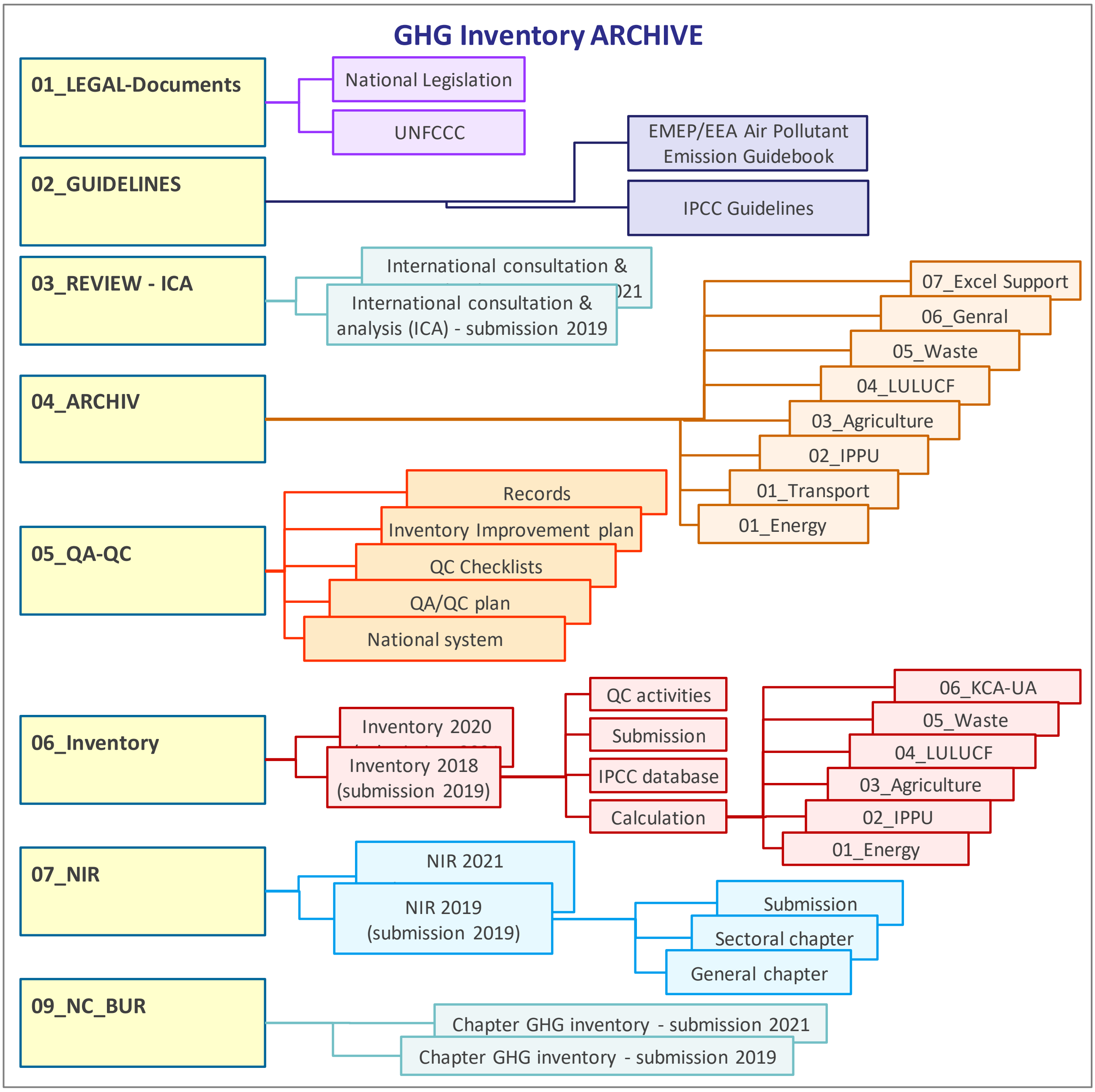


Figure 15 GHG Inventory Archive

1.6.6 Treatment of confidentiality issues

Information or data is declared as confidential when it could directly or indirectly identify an individual person, business or organization. Following the Statistics Law[40] Article 18 confidential data should not be published. To ensure completeness confidential data may be used to estimation of GHG emissions and removal, but these emissions can be reported at a higher aggregated level so that confidentiality is no longer an issue.

The checklist *Confidential data*, which is presented in the next Table, should be used in order to ensure, that confidential data used in the inventory is not published.

In the current GHG Inventory no confidential data are used.

Table 29 Checklist - Confidential data

	CHECKLIST CONFIDENTIAL DATA according to IPCC 2006 Guidelines - Chapter 6					
1	Submission:		Source / Sink Category:			
2	DATA USE					
3	Title of calculation sheets / internal_documentation / NIR / CTR					
4	Insert of data path/folder					
5	Source/sink category estimates prepared by (name):					
6	Source of confidential data					
7	Description of confidential data					
8	RELEASE OF RESULTS			YES	NO	Comment
9	Data in calculations sheets (Background calculation) visible / marked as confidential data					
10	Data in NAI table / CTR visible directly or indirectly or marked as confidential data (example in „Recalculations“)					
11	Data in NIR not reproducible					
12	RESULTS	confidentiality ensured, publication of results allowed				
13		confidentiality not ensured, publication of results not allowed				
14		Remarks				
15		If confidentiality not ensured, publication of results not allowed				
16		required action / measurements (e.g. higher aggregation)				
17	DATA USED / Acknowledgement of confidential data					
18	Date		Signature (sector expert)			
19	Date		Signature (National Inventory Compiler (NIC))			

[40] NSIA (2016): Official Gazette 1238 from 05 Dec 2016; based on 1110. Date: 3rd JULY 2013, ISSUE NO: 1110 Kabul. http://old.moj.gov.af/Content/files/OfficialGazette/01101/OG_01110.pdf

1.7 General uncertainty evaluation

According to the 2006 IPCCC Guidelines, Volume 1, Chapter 3, uncertainty estimates are an essential element of a complete inventory of greenhouse gas emissions and removals and requires a detailed understanding of the uncertainties of the respective input parameters. They should be derived for both the national level and the trend estimate, as well as for the component parts such as emission factors, activity data and other estimation parameters for each category.

Principally, two different TIERS for the estimation of combined uncertainties are presented in the IPCC GPG: TIER 1 uses simple error propagation equations, while TIER 2 uses Monte Carlo.

TIER 1 is based upon error propagation and is used to estimate uncertainty in individual categories, in the inventory as a whole, and in trends between a year of interest and a base year. TIER 1 should be implemented using Table 3.2 of the IPCC Guidelines (2006), Vol. 1, Chap. 3.

For the current submission the uncertainty calculation was performed applying approach 1 of the IPCC 2006 Guidelines, for all sectors. As a result of the uncertainty analysis, the following table shows

- a combined uncertainty of total national emissions in year 2017 of 24.04%,
- an uncertainty introduced into the trend in total national emissions of 81.74%.

The above-mentioned uncertainties are quite high. The largest uncertainty comes from the domestic and transport sector but also from sector agriculture and waste.

The respective sectoral uncertainties are documented in detail in the sectoral chapters of this report.

Uncertainty information was taken mainly from 2006 IPCC Guidelines as especially for all default emission factors also related uncertainties were provided.

Table 30 Uncertainty calculation according to TIER 1

	A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Code	**IPCC category**	**Gas**	**Base year emissions 1990**	**Year 2011 emissions**	**Activity data uncertainty**	**Emission factor uncertainty**	**Combined uncertainty**	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Input data	Input data	Input data	Input data	√ (E^2 + F^2)	G * D / ∑D	Note B	D / ∑C	I * F Note C	J * E * √2 Note D	√ (K^2 + L2)
			Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%	%	%	%	%	%	%
1.A.1.a	Main Activity Electricity and Heat Production	CO_2	44.93	42.02	2.0	2.0	2.8	0.00	0.00	0.00	0.01	0.01	0.01
1.A.1.b	Petroleum Refining	CO_2	0.82	3.41	10.0	2.0	10.2	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.c	Manufacture of Solid Fuels and Other Energy Industries	CO_2	0.00	47.87	10.0	25.0	26.9	0.03	0.00	0.00	0.09	0.04	0.10
1.A.2.c	Chemicals	CO_2	243.43	176.88	10.0	20.0	22.4	0.09	-0.02	0.01	0.28	0.14	0.31
1.A.2.m	Other(1.A.2.m)	CO_2	293.48	5,747.51	10.0	7.0	12.2	1.61	0.28	0.32	3.15	4.49	5.49
1.A.3.a.ii	Domestic Aviation	CO_2	397.30	177.84	10.0	5.0	11.2	0.05	-0.04	0.01	0.07	0.14	0.16
1.A.3.b	Road Transportation	CO_2	3,717.22	12,703.16	50.0	2.0	50.0	14.62	0.21	0.70	1.99	49.67	49.71
1.A.4.b	Residential	CO_2	173.37	1,704.65	110.7	5.2	110.8	4.34	0.07	0.09	0.69	14.76	14.77
1.B.2.a	Oil	CO_2	0.00	0.02	20.0	30.0	36.1	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.b	Natural Gas	CO_2	15.67	11.69	20.0	30.0	36.1	0.01	0.00	0.00	0.03	0.02	0.03
2.A.1	Cement production	CO_2	45.77	44.78	10.0	35.0	36.4	0.04	0.00	0.00	0.12	0.04	0.13
2.A.2	Lime production	CO_2	0.00	36.90	10.0	3.0	10.4	0.01	0.00	0.00	0.01	0.03	0.03
2.B.1	Ammonia Production	CO_2	168.93	130.67	10.0	10.0	14.1	0.04	-0.02	0.01	0.10	0.10	0.14
2.D.1	Lubricant Use	CO_2	33.41	33.41	20.0	50.1	53.9	0.04	0.00	0.00	0.13	0.05	0.14
2.D.2	Paraffin Wax Use	CO_2	0.02	0.02	20.0	50.1	53.9	0.00	0.00	0.00	0.00	0.00	0.00
3.H	Urea application	CO_2	53.73	67.92	10.0	50.0	51.0	0.08	0.00	0.00	0.27	0.05	0.27
5.C	Incineration and Open Burning of Waste	CO_2	3.03	6.25	147.0	40.0	152.3	0.02	0.00	0.00	0.02	0.07	0.07
1.A.1.a	Main Activity Electricity and Heat Production	CH_4	0.04	0.04	2.0	20.0	20.1	0.00	0.00	0.00	0.00	0.00	0.00

	A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Code	**IPCC category**	**Gas**	**Base year emissions 1990**	**Year 2011 emissions**	**Activity data uncertainty**	**Emission factor uncertainty**	**Combined uncertainty**	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Input data	Input data	Input data	Input data	√ $(E^2 + F^2)$	G * D / ∑D	Note B	D / ∑C	I * F Note C	J * E * √2 Note D	√ (K^2 + L2)
			Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%	%	%	%	%	%	%
1.A.1.b	Petroleum Refining	CH_4	0.00	0.00	10.0	100.0	100.5	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.c	Manufacture of Solid Fuels and Other Energy Industries	CH_4	28.76	314.62	27.0	78.0	82.5	0.60	0.01	0.02	1.92	0.66	2.03
1.A.2.c	Chemicals	CH_4	0.11	0.08	10.0	100.0	100.5	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.m	Other(1.A.2.m)	CH_4	0.57	13.73	10.0	100.0	100.5	0.03	0.00	0.00	0.11	0.01	0.11
1.A.3.a.ii	Domestic Aviation	CH_4	0.07	0.03	10.0	22.0	24.2	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b	Road Transportation	CH_4	15.91	70.73	50.0	100.0	111.8	0.18	0.00	0.00	0.55	0.28	0.62
1.A.4.b	Residential	CH_4	202.52	330.37	110.7	173.2	205.5	1.56	-0.01	0.02	4.48	2.86	5.31
1.B.1	Solid Fuels	CH_4	32.73	37.27	20.0	30.0	36.1	0.03	0.00	0.00	0.09	0.06	0.11
1.B.2.a	Oil	CH_4	0.33	1.34	20.0	30.0	36.1	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.b	Natural Gas	CH_4	7.69	5.73	20.0	30.0	36.1	0.00	0.00	0.00	0.01	0.01	0.02
3.A.1	Enteric Fermentation	CH_4	4,976.19	10,273.23	20.0	40.0	44.7	10.57	-0.09	0.57	32.14	16.07	35.93
3.B.2	Manure Management	CH_4	1,844.78	2,045.68	42.9	30.0	52.4	2.47	-0.13	0.11	4.80	6.87	8.38
3.C	Rice Cultivation	CH_4	1,623.18	2,040.57	20.0	60.0	63.2	2.97	-0.10	0.11	9.58	3.19	10.09
3.F	Field burning of agricultural residues	CH_4	7.11	16.82	20.0	180.0	181.1	0.07	0.00	0.00	0.24	0.03	0.24
5.A	Solid Waste Disposal	CH_4	131.72	216.36	147.0	98.0	176.7	0.88	-0.01	0.01	1.66	2.49	2.99
5.B	Biological Treatment of Solid Waste	CH_4	11.82	31.56	147.0	50.0	155.3	0.11	0.00	0.00	0.12	0.36	0.38
5.C	Incineration and Open Burning of Waste	CH_4	0.90	1.87	147.0	100.0	177.8	0.01	0.00	0.00	0.01	0.02	0.03
5.D	Wastewater Treatment and Discharge	CH_4	674.73	1,018.49	71.0	129.0	147.2	3.45	-0.03	0.06	10.28	5.66	11.73

	A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Code	**IPCC category**	**Gas**	**Base year emissions 1990**	**Year 2011 emissions**	**Activity data uncertainty**	**Emission factor uncertainty**	**Combined uncertainty**	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Input data	Input data	Input data	Input data	√ (E² + F²)	G * D / ∑D	Note B	D / ∑C	I * F Note C	J * E * √2 Note D	√ (K² + L2)
			Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%	%	%	%	%	%	%
1.A.1.a	Main Activity Electricity and Heat Production	N2O	0.11	0.10	2.0	100.0	100.0	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.b	Petroleum Refining	N2O	0.00	0.00	10.0	20.0	22.4	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.c	Chemicals	N2O	0.13	0.09	10.0	20.0	22.4	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.m	Other(1.A.2.m)	N2O	1.09	24.47	10.0	10.0	14.1	0.01	0.00	0.00	0.02	0.02	0.03
1.A.3.a.ii	Domestic Aviation	N2O	3.31	1.48	10.0	40.0	41.2	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b	Road Transportation	N2O	56.30	183.38	50.0	20.0	53.9	0.23	0.00	0.01	0.29	0.72	0.77
1.A.4.b	Residential	N2O	31.77	50.92	110.7	34.6	116.0	0.14	0.00	0.00	0.14	0.44	0.46
1.B.2.a	Oil	N2O	0.00	0.00	20.0	30.0	36.1	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.b	Natural Gas	N2O	0.00	0.00	20.0	30.0	36.1	0.00	0.00	0.00	0.00	0.00	0.00
3.B.2	Manure Management	N2O	102.77	137.91	42.9	250.0	253.7	0.80	-0.01	0.01	2.70	0.46	2.74
3.D.a.1	Inorganic N fertilizers	N2O	343.11	433.71	20.0	250.0	250.8	2.50	-0.02	0.02	8.48	0.68	8.51
3.D.a.2	Organic N fertilizers	N2O	149.12	206.03	20.0	200.0	201.0	0.95	-0.01	0.01	3.22	0.32	3.24
3.D.a.3	Urine and dung deposited by grazing animals	N2O	359.35	811.13	42.9	50.0	65.9	1.23	0.00	0.04	3.17	2.72	4.18
3.D.a.4	Crop residues	N2O	1,531.15	2,902.27	20.0	180.0	181.1	12.09	-0.04	0.16	40.86	4.54	41.11
3.D.b	Indirect N2O Emissions from managed soils	N2O	637.53	1,133.86	42.9	250.0	253.7	6.62	-0.02	0.06	22.17	3.81	22.49
3.F	Field burning of agricultural residues	N2O	1.75	4.78	20.0	180.0	181.1	0.02	0.00	0.00	0.07	0.01	0.07
5.B	Biological Treatment of Solid Waste	N2O	8.45	22.57	147.0	50.0	155.3	0.08	0.00	0.00	0.09	0.26	0.27
5.C	Incineration and Open Burning of Waste	N2O	10.07	20.75	147.0	100.0	177.8	0.08	0.00	0.00	0.16	0.24	0.29

	A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Code	**IPCC category**	**Gas**	**Base year emissions 1990**	**Year 2011 emissions**	**Activity data uncertainty**	**Emission factor uncertainty**	**Combined uncertainty**	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Input data	Input data	Input data	Input data	$\sqrt{(E^2 + F^2)}$	G * D / ∑D	Note B	D / ∑C	I * F Note C	J * E * √2 Note D	$\sqrt{(K^2 + L2)}$
			Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%	%	%	%	%	%	%
5.D	Wastewater Treatment and Discharge	N2O	96.99	184.43	71.0	261.0	270.5	1.15	0.00	0.01	3.76	1.02	3.90
	Total Categories excluding LULUCF	Gg CO_2 e	**18,083**	**43,471**				**24.04**					**81.74**
	% of Total		100.0%	100.0%									

1.8 General assessment of the completeness

The sources and sinks not considered in the inventory but included in the IPCC 2006 Guidelines are clearly indicated, the reasons for such exclusion are explained. Notation keys - NA, NO, NE, IE - used are in accordance with the 2006 IPCC Guidelines, Volume 1: General Guidance and Reporting, Chapter 8: Reporting Guidance and Tables, TABLE 8, page 8.7.

Sources and sinks All sources and sinks included in the IPCC 2006 Guidelines are addressed. No additional sources and sinks specific to Afghanistan have been identified.

Currently the following GHGs source and sink categories could not be estimated due to lack of data and resources:

Energy - Heat Plants, Military, Multilateral Operations

IPPU - Brick Production, Nitric Acid Production, Solvents, Consumption of Halocarbons and SF6, Other Product Manufacture and Use
Land Use, Land-Use Change and Forestry (LULUCF)

Waste - Industrial Wastewater, Incineration of Industrial Waste, Hazardous Waste, Clinical Waste

Gases Both direct GHGs as well as precursor gases are covered by the GHG inventory of Afghanistan. As mentioned above, currently all sources emitting fluorocarbons could not be estimated due to lack of data and resources.

Geographic coverage The geographic coverage is complete. There is no part of the Afghanistan's territory not covered by the inventory.

1.9 Global warming potentials (GWP)

The aggregated greenhouse gases (GHG in CO_2 equivalents) are prepared using the global warming potentials (GWP) provided by the IPCC Fourth Assessment Report (AR4)[41] based on the effects of GHGs over a 100-year time horizon.

Table 31 Global warming potentials (GWP) provided by the IPCC Fourth Assessment Report (AR4).

Gas name	Chemical formula / Abbreviation	Global Warming Potential (Time Horizon) based on the effects of GHGs over a 100-year time horizon
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298
Sulphur hexafluoride	SF_6	23,800
Hydrofluorocarbons	HFC	hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) consist of different substances, therefore GWPs have to be calculated individually depending on the substances
Perfluorocarbons	PFC	
Nitrogen trifluoride	NFH_3	17,200

[41] IPCC. (2007). *Climate Change 2007 - The Physical Science Basis Contribution of Working Group I to the Fourth Assessment Report of the IPCC. (Table TS.2)*. Available (12 May 2019) at: https://www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf

1.10 Relationship / Conversion of Solar Hijri calendar - Gregorian calendar

The Afghan official calendar is based on a solar year (Solar Hijri calendar) starting on 21st March in the Gregorian calendar. The Gregorian calendar was used for preparation of the GHG inventory whereas some activity data (e.g. national statistics) follows the official calendar of Afghanistan. A notice which calendar was used is always provided.

In the following table the Afghan months are listed.

Table 32 Relationship between Afghan official calendar and Gregorian calendar

Name of Afghan month	Start according to Gregorian calendar	End according to Gregorian calendar	Number of days	Name of Gregorian month
Hamal	21st March	20th April	31	April
Sawr	21st April	21st May	31	May
Jawza	22nd May	21st June	31	June
Saratan	22nd June	22nd July	31	July
Asad	23rd July	22nd August	31	August
Sunbula	23rd August	22nd September	31	September
Miezan	23rd September	22nd October	30	October
Aqrab	23rd October	21st November	30	November
Qaws	22nd November	21st December	30	December
Jadi	22nd December	20th January	30	January
Dalwa	21st January	19th February	30	February
Hut	20th February	20th March	29/30	March

In the following figure the conversion of Afghan official calendar to Gregorian calendar is illustrated.

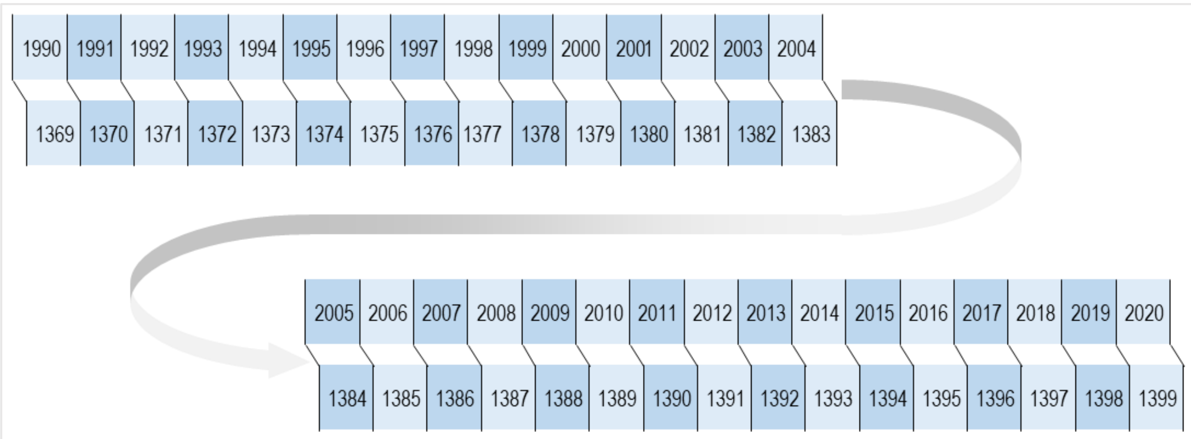


Figure 16 Conversion of Afghan official calendar to Gregorian calendar

In the following table the conversion from Afghan months to Gregorian months are listed.

Table 33 Conversion of Afghan official calendar to Gregorian calendar and vis versa

Gregorian calendar	Start according	End according		Solar Hijiri calendar	Start according	End according
	to Solar Hijiri calendar				to Gregorian calendar	
1990	11.10.1368	10.10.1369		**1368**	21.03.1989	20.03.1990
1991	11.10.1369	10.10.1370		**1369**	21.03.1990	20.03.1991
1992	11.10.1370	10.10.1371		**1370**	21.03.1991	20.03.1992
1993	11.10.1371	10.10.1372		**1371**	21.03.1992	20.03.1993
1994	11.10.1372	10.10.1373		**1372**	21.03.1993	20.03.1994
1995	11.10.1373	10.10.1374		**1373**	21.03.1994	20.03.1995
1996	11.10.1374	11.10.1375		**1374**	21.03.1995	20.03.1996
1997	12.10.1375	10.10.1376		**1375**	21.03.1996	20.03.1997
1998	11.10.1376	10.10.1377		**1376**	21.03.1997	20.03.1998
1999	11.10.1377	10.10.1378		**1377**	21.03.1998	20.03.1999
2000	11.10.1378	11.10.1379		**1378**	21.03.1999	20.03.2000
2001	12.10.1379	10.10.1380		**1379**	21.03.2000	20.03.2001
2002	11.10.1380	10.10.1381		**1380**	21.03.2001	20.03.2002
2003	11.10.1381	10.10.1382		**1381**	21.03.2002	20.03.2003
2004	11.10.1382	11.10.1383		**1382**	21.03.2003	20.03.2004
2005	12.10.1383	10.10.1384		**1383**	21.03.2004	20.03.2005
2006	11.10.1384	10.10.1385		**1384**	21.03.2005	20.03.2006
2007	11.10.1385	10.10.1386		**1385**	21.03.2006	20.03.2007
2008	11.10.1386	11.10.1387		**1386**	21.03.2007	20.03.2008
2009	12.10.1387	10.10.1388		**1387**	21.03.2008	20.03.2009
2010	11.10.1388	10.10.1389		**1388**	21.03.2009	20.03.2010
2011	11.10.1389	10.10.1390		**1389**	21.03.2010	20.03.2011
2012	11.10.1390	11.10.1391		**1390**	21.03.2011	20.03.2012
2013	12.10.1391	10.10.1392		**1391**	21.03.2012	20.03.2013
2014	11.10.1392	10.10.1393		**1392**	21.03.2013	20.03.2014
2015	11.10.1393	10.10.1394		**1393**	21.03.2014	20.03.2015
2016	11.10.1394	11.10.1395		**1394**	21.03.2015	20.03.2016
2017	12.10.1395	10.10.1396		**1395**	21.03.2016	20.03.2017
2018	11.10.1396	10.10.1397		**1396**	21.03.2017	20.03.2018
2019	11.10.1397	10.10.1398		**1397**	21.03.2018	20.03.2019
2020	11.10.1398	11.10.1399		**1398**	21.03.2019	20.03.2020

2 Trend description

Afghanistan's total National greenhouse gas (GHG) emissions (without LULUCF) amounted in 2017 to 43,471.39 Gg CO_2 equivalents (CO_2 eq). Compared to 2005 the GHG emissions increased by 93.6 % and compared to 1990 the GHG emissions increased by 140.5 %. In 2005 the GHG emissions (without LULUCF) amounted to 22,453.86 Gg CO_2 equivalents (CO_2 eq) and in 1990 the GHG emissions (without LULUCF) amounted to 18,076.57 Gg CO_2 equivalents (CO_2 eq).

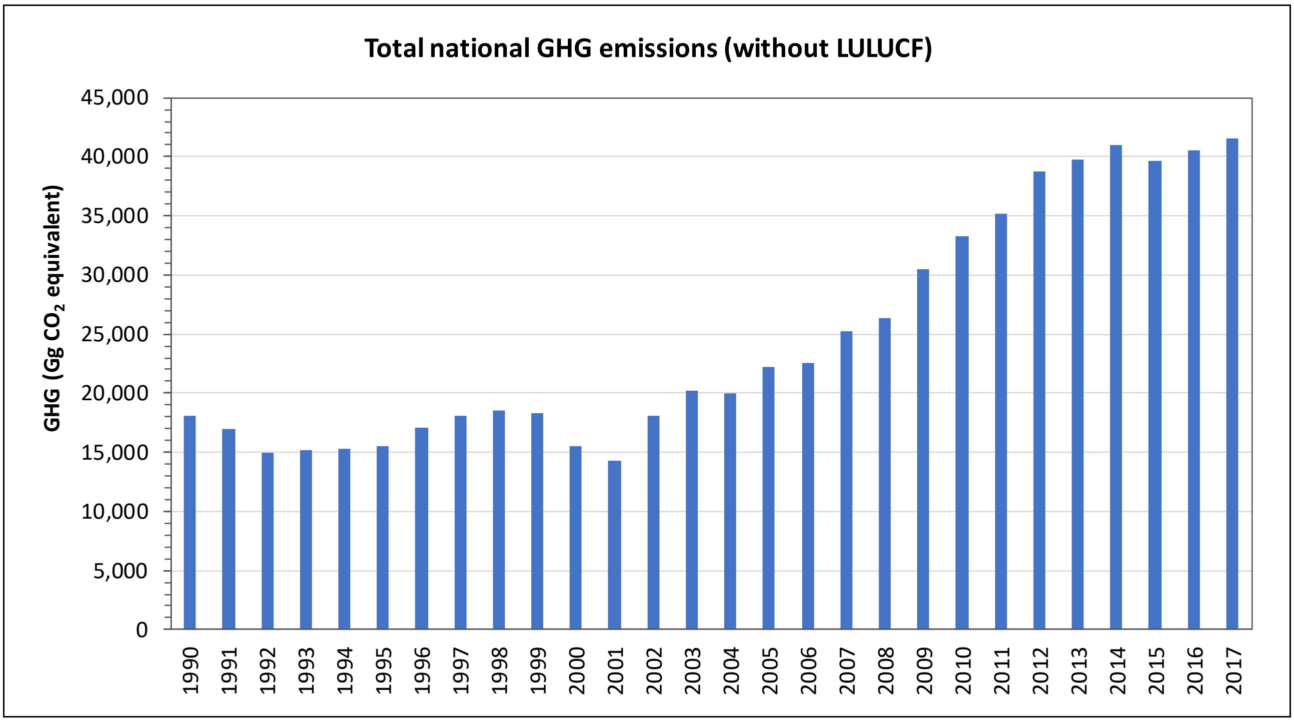


Figure 17 Total national GHG emissions (without LULUCF) in CO_2 equivalent

The most important GHG in Afghanistan is carbon dioxide (CO_2) with a share of 48.2% in 2017. The CO_2 emissions primarily result from fuel combustion activities; methane (CH_4), which mainly arises from livestock farming, contributes to 37.8% of the national total GHG emissions, and nitrous oxide (N_2O) with agricultural soils as the main source contributes to the remaining 14.1% in 2017.

In 2005, the most important GHG was CH_4 with a share of 54.6%, followed by N_2O with 24.2%. CO_2 was at that time only responsible for 21.3% of the total GHG emissions.

In 1990 (as in 2005), CH_4 emissions from livestock farming had a share of 52.9% of total GHG emissions. CO_2 emissions mainly from fuel combustion contributed with 28.7%, and N_2O contributed with 18.4% total GHG emissions.

These changes in the contribution of the specific GHGs to total emissions were driven by the War in Afghanistan, leading in earlier year to less power production from fossil fuels, and thereby to lower CO_2 emissions.

Table 34 Trend of GHG emissions by sources and removals by sinks for 1990 – 2017.

Inventory Years	Total GHG	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
	Gg CO_2 equivalent				Share in Total national GHG [%]		
1990	18,076.57	5,191.09	9,559.16	3,326.32	28.7%	52.9%	18.4%
1991	16,950.69	4,836.86	8,764.15	3,349.68	28.5%	51.7%	19.8%
1992	15,013.80	3,052.88	8,840.06	3,120.86	20.3%	58.9%	20.8%
1993	15,278.60	2,940.36	8,915.04	3,423.20	19.2%	58.3%	22.4%
1994	15,333.75	2,801.99	9,200.35	3,331.41	18.3%	60.0%	21.7%
1995	15,594.85	2,694.49	9,511.75	3,388.61	17.3%	61.0%	21.7%
1996	17,175.07	2,940.91	10,693.21	3,540.95	17.1%	62.3%	20.6%
1997	18,152.90	2,724.10	11,501.50	3,927.29	15.0%	63.4%	21.6%
1998	18,691.28	2,568.82	12,016.19	4,106.26	13.7%	64.3%	22.0%
1999	18,366.46	1,826.22	12,694.91	3,845.33	9.9%	69.1%	20.9%
2000	15,627.54	1,855.62	11,036.64	2,735.28	11.9%	70.6%	17.5%
2001	14,371.22	2,028.25	9,544.97	2,798.00	14.1%	66.4%	19.5%
2002	18,165.04	2,302.08	11,701.77	4,161.20	12.7%	64.4%	22.9%
2003	20,153.14	3,502.66	11,983.85	4,666.63	17.4%	59.5%	23.2%
2004	20,163.62	3,971.28	12,158.89	4,033.45	19.7%	60.3%	20.0%
2005	22,453.86	4,774.58	12,255.60	5,423.67	21.3%	54.6%	24.2%
2006	22,854.61	5,514.59	12,503.53	4,836.49	24.1%	54.7%	21.2%
2007	25,678.10	6,944.15	12,952.82	5,781.14	27.0%	50.4%	22.5%
2008	27,303.07	8,643.45	14,154.21	4,505.41	31.7%	51.8%	16.5%
2009	31,793.03	10,542.10	14,615.20	6,635.72	33.2%	46.0%	20.9%
2010	36,102.42	13,201.51	16,491.98	6,408.93	36.6%	45.7%	17.8%
2011	35,799.66	13,722.25	16,465.48	5,611.93	38.3%	46.0%	15.7%
2012	39,924.62	16,770.99	16,109.71	7,043.92	42.0%	40.4%	17.6%
2013	41,003.34	17,604.73	16,024.83	7,373.78	42.9%	39.1%	18.0%
2014	42,195.75	18,150.92	16,656.36	7,388.47	43.0%	39.5%	17.5%
2015	41,995.19	18,993.95	16,297.70	6,703.54	45.2%	38.8%	16.0%
2016	42,880.77	20,045.39	16,312.58	6,522.81	46.7%	38.0%	15.2%
2017	43,471.39	20,934.98	16,418.51	6,117.89	48.2%	37.8%	14.1%
Trend 1990-2017	140.5%	303.3%	71.8%	83.9%			
Trend 2005-2017	93.6%	338.5%	34.0%	12.8%			
Trend 2012-2017	8.9%	24.8%	1.9%	-13.1%			
Trend 2016-2017	1.4%	4.4%	0.6%	-6.2%			

Remark: Due to lack of data and resources fluorinated gases HFCs, PFCs, SF_6, NF_3 are not estimate.

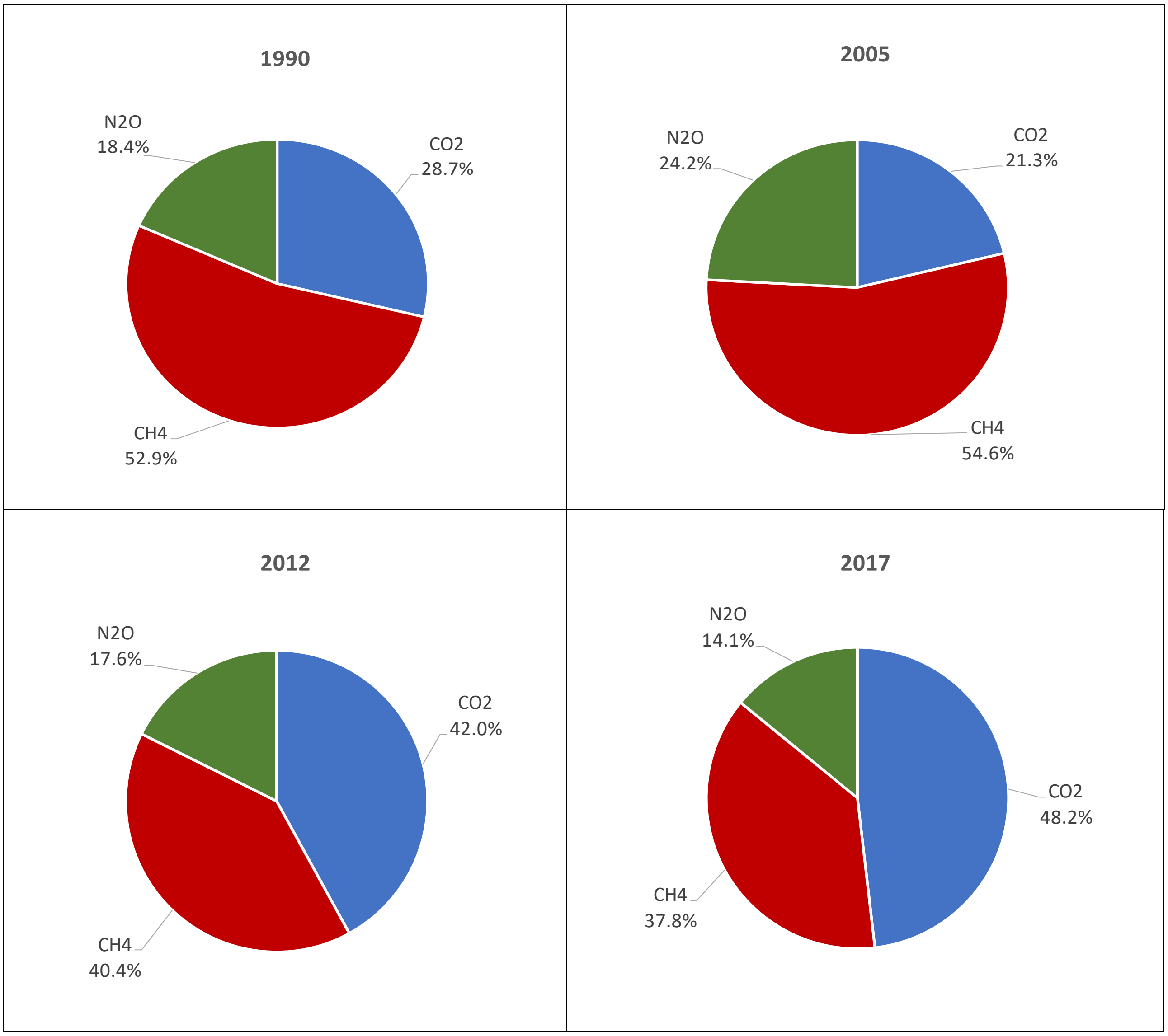


Figure 18 **Share of CO_2, CH_4 and N_2O in Total national greenhouse gas emissions in 1990, 2005, 2012 and 2017**

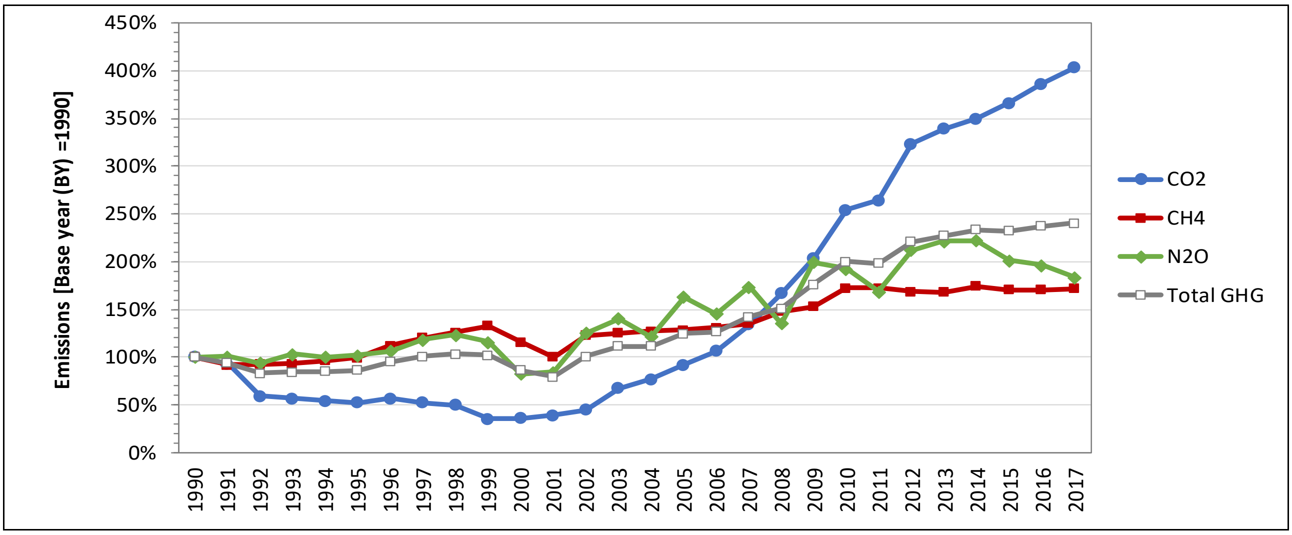


Figure 19 **Trend of CO_2, CH_4 and N_2O emissions and Total national GHG emissions in index form (base year = 100) by IPCC sector for the period 1990 . 2017**

2.1 Emission trend by gas

2.1.1 Carbon Dioxide (CO_2)

CO_2 emissions increased by 403% from 1990 to 2017, in recent year the strong increase slowed down. In the period 2005 – 2017 CO_2 emissions increased by 438%. In absolute figures, CO_2 emissions increased during the period

- 1990 to 2017 from 5,191,09 Gg to 20,934.98 Gg (+403%),
- 2005 to 2017 from 4,774.58 Gg to 20,934.98 Gg (+438%),
- 2012 to 2017 from 16,770.99 Gg to 20,934.98 Gg (+125%),
- 2016 to 2017 from 20,045,39 Gg to 20,934.98 Gg (+4.4%).

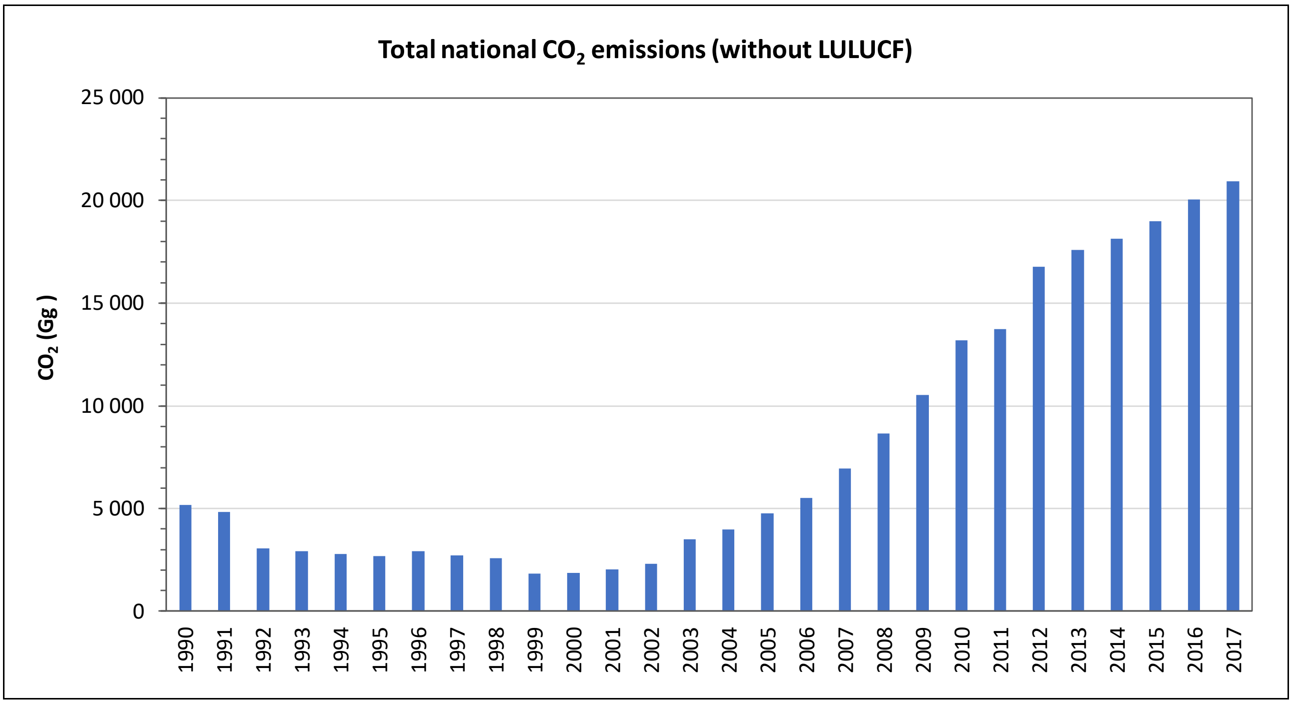


Figure 20 Total national CO_2 emissions

In 2017, the main source of CO_2 emissions in Afghanistan with a share of 98.4% is the category 1.A Fuel Combustion Activities; within the category 1.A Fuel Combustion Activities, the subcategory 1.A.3 Transport is the most important sub-source with a share of 61.5%.

The share of CO_2 emissions from fossil fuel combustion is for the whole time series above 90%, starting in 1990 with a share of 93.8%. In 2005 and also in 1990, the transport sector 1A3 was the biggest source of CO_2 emissions. The transport sector had a share of 79.3% of total CO_2 emissions in 1990, and a share of 82.8% in 2005.

2.1.2 Methane (CH_4)

CH_4 emissions increased significantly during the period from 1990 to 2017 from 9,559.16 Gg CO_2 equivalents to 16,418.51 Gg CO_2 equivalents. In 2017, CH_4 emissions were 71.8% above the level of 1990, mainly due to increasing emissions from the category 3.A Enteric Fermentation (+106.4%), 4.C Rice Cultivation (+25.7%) and 3.B Manure Management (+10.9%), which are also the main sources of CH_4 emissions in Afghanistan.

During the period from 2005 to 2017 CH_4 emissions increased from 12,255.60 Gg CO_2 equivalents to 16,418.51 Gg CO_2 equivalents, which is 34,0% above the level of 2005. The main reason for these increases is the are the categories 3.A. Enteric Fermentation (+31.5%), 3.B. Manure Management (32.5%) and 3.C Rice Cultivation (+37,5%). CH_4 emissions from 3.A Enteric Fermentation also had the highest share, namely 62.6%, in 2005.

In recent year CH_4 emissions are relatively stable, with an increase of 0.6% between 2016 and 2017.

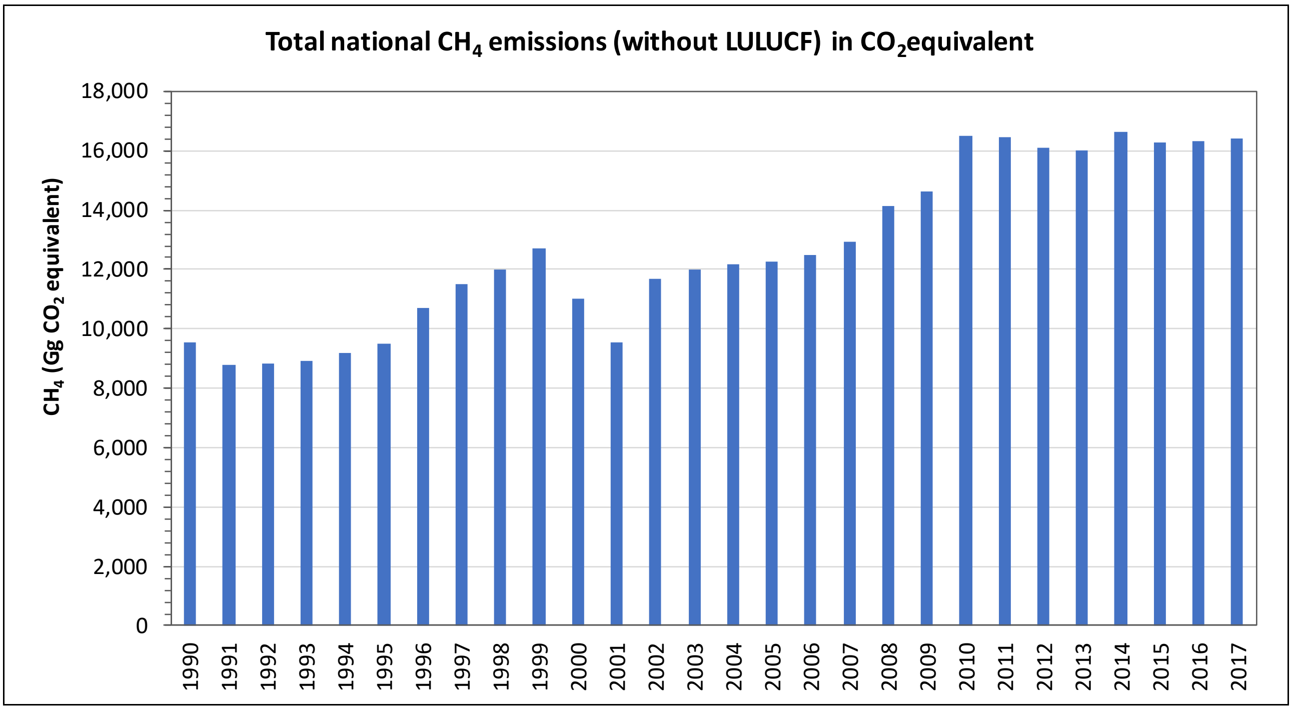


Figure 21 Total national CH_4 emissions in CO_2 equivalent

2.1.3 Nitrous Oxide (N_2O)

N_2O emissions show a strong increase of 83.9%, resulting in 6,117.89 Gg CO_2 equivalents in 2017 compared to 3,326.32 Gg CO_2 equivalents in 1990. The increase is mainly due to higher N_2O emissions from the category 3.D Agricultural Soils.

During the period from 2005 to 2017 N_2O emissions increased marginally from 5,423.67 Gg CO_2 equivalents to 6,117.89 Gg CO_2 equivalents. In 2017, N_2O emissions were 12.8% above the level of 2005, mainly due to increasing emissions from the category 3.D Agricultural Soils .

Between 2016 and 2017, N_2O emissions show a decreasing trend of -6.2% between 2016 – 2017 which is mainly a result of lower N_2O emissions from the category 3.D Agricultural Soils.

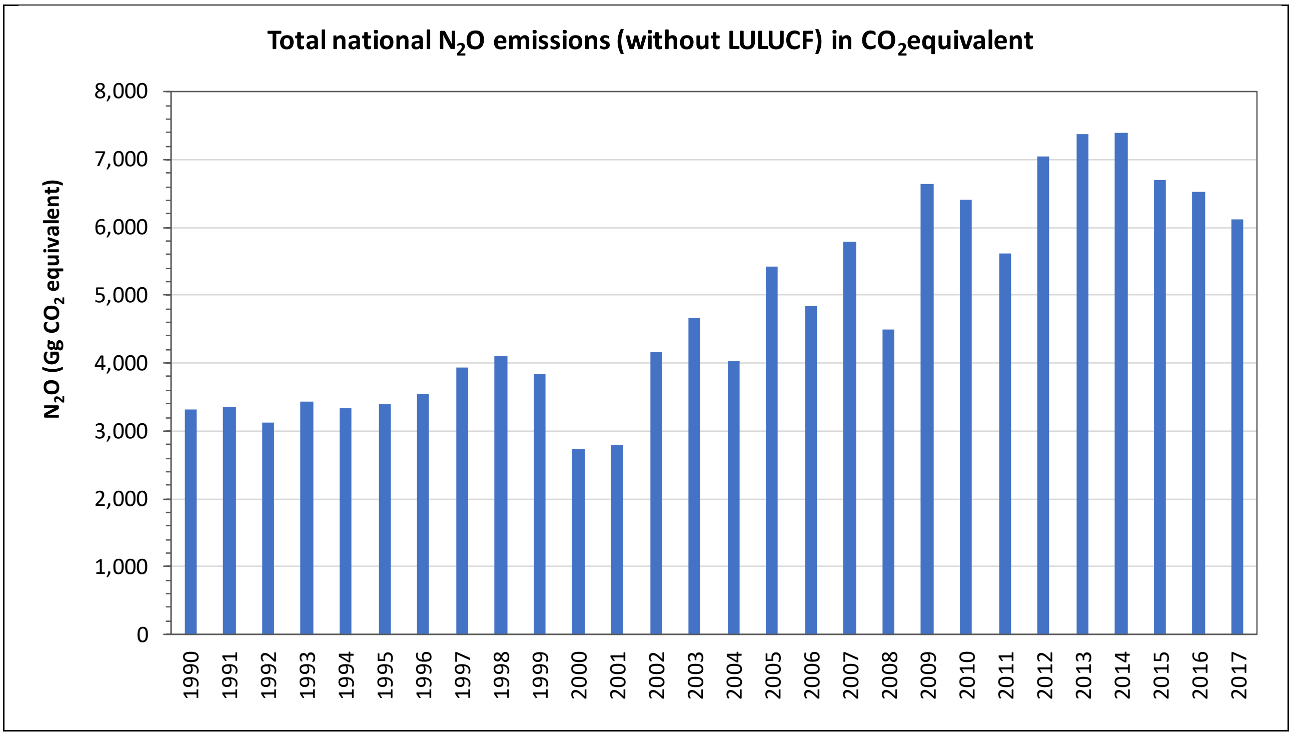


Figure 22 **Total national N_2O emissions in CO_2 equivalent**

The main source of N_2O emissions in all years is the category 3.D Agricultural Soils, contributing in 1990 with a share of 90.8% and in 2017 with a share of 89.7% to national total N_2O emissions. In 2017, the sub-category 1.A.3. Transport and the sub-category 5.B Wastewater Treatment and Discharge have each a share of 3%, followed by 3.B Manure management with 2.3%.

2.1.4 Carbon monoxide (CO)

Carbon monoxide (CO) is mainly formed when fuels containing carbon (e.g. gasoline, natural gas, oil, coal, and wood) are burnt in conditions where oxygen is limited (incomplete combustion). Anthropogenic sources of CO emissions are mainly vehicle emissions, burning in households' applicants (e.g. small boilers, gas fires, cookers) and open burning.

CO emissions increased by 179% from 1990 to 2017. In absolute figures, CO emissions increased from 324.39 Gg to 903.96 Gg during the period from 1990 to 2017 mainly due to higher CO emissions from category 1.A.3 Transport (+248%) as well as from 1.A.4 Other Sectors (households) (+123%).

During the period from 2005 to 2017 CO emissions increased from 432.12 Gg to 903.96 Gg. In 2017, CO emissions were 109% above the level of 2005, mainly due to increasing emissions from the category 1A3 Transport.

The category 1A2 Manufacturing Industries and Construction showed the highest increase (>2,800%) since 1990, having in 2017 a share in the total CO emissions of 6.8%.

Between 2016 and 2017, CO emissions increased by 2.94%reasing trend of 13% between 2016 – 2017 which is mainly a result of higher CO emissions from category 1A4 Other sectors (households) and 1A2 Manufacturing Industries and Construction.

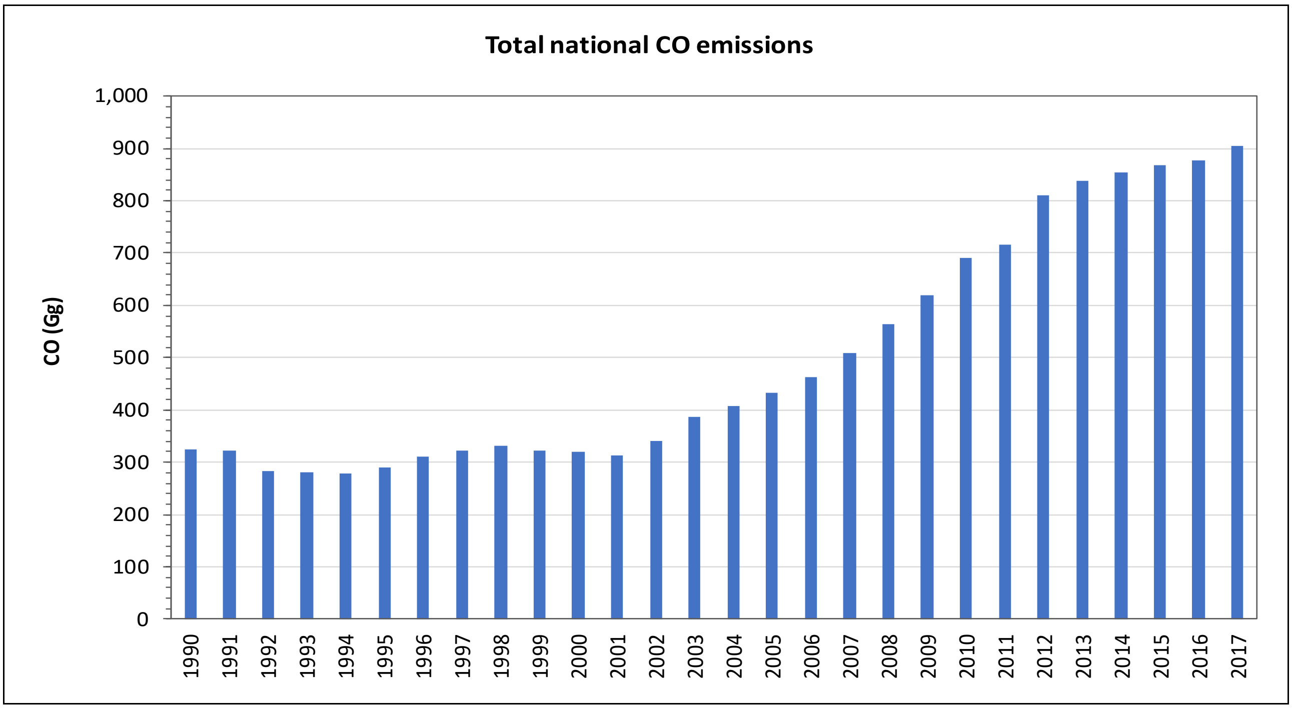


Figure 23 **Total national CO emissions**

2.1.5 Nitrogen Oxide (NOx)

Nitrogen oxides refers to nitric oxide gas (NO) and nitrogen dioxide gas (NO2) and many other gaseous oxides containing nitrogen. Nitrogen Oxide (NOx) is mainly formed and released in all common types of combustion. The main sources of these gases are exhaust gases from motor vehicle and combustion in boilers for energy production and in in the industry. Once NOx introduced into the atmosphere from car exhausts, furnace stacks, incinerators, power stations and similar sources, the oxides include nitrous oxide, nitric oxide, nitrogen dioxide, nitrogen pentoxide and nitric acid. The oxides of nitrogen undergo many reactions in the atmosphere to form photochemical smog.

NO_x emissions increased strongly during the period 1990 to 2017 from 200.32 Gg to 634.13 Gg. In 2017, NO_X emissions were 217% above the level of 1990, mainly due to increasing emissions from the category 1.A.4 Other sectors (households) (+215%).

During the period from 2005 to 2017 NO_X emissions increased from 310.32 Gg to 634.13 Gg. In 2017, NO_X emissions were 104% above the level of 2005, mainly due to increasing emissions from the category 1.A.4 Other sectors (households).

Between 2016 and 2017, NO_x emissions increased by 7%. The highest share of NOx emissions in 2017 results from 1.A.4 Other sectors (households) with 91.1%, followed by category 1.A.3 Transport with a share of 5.9% of total NO_x emissions.

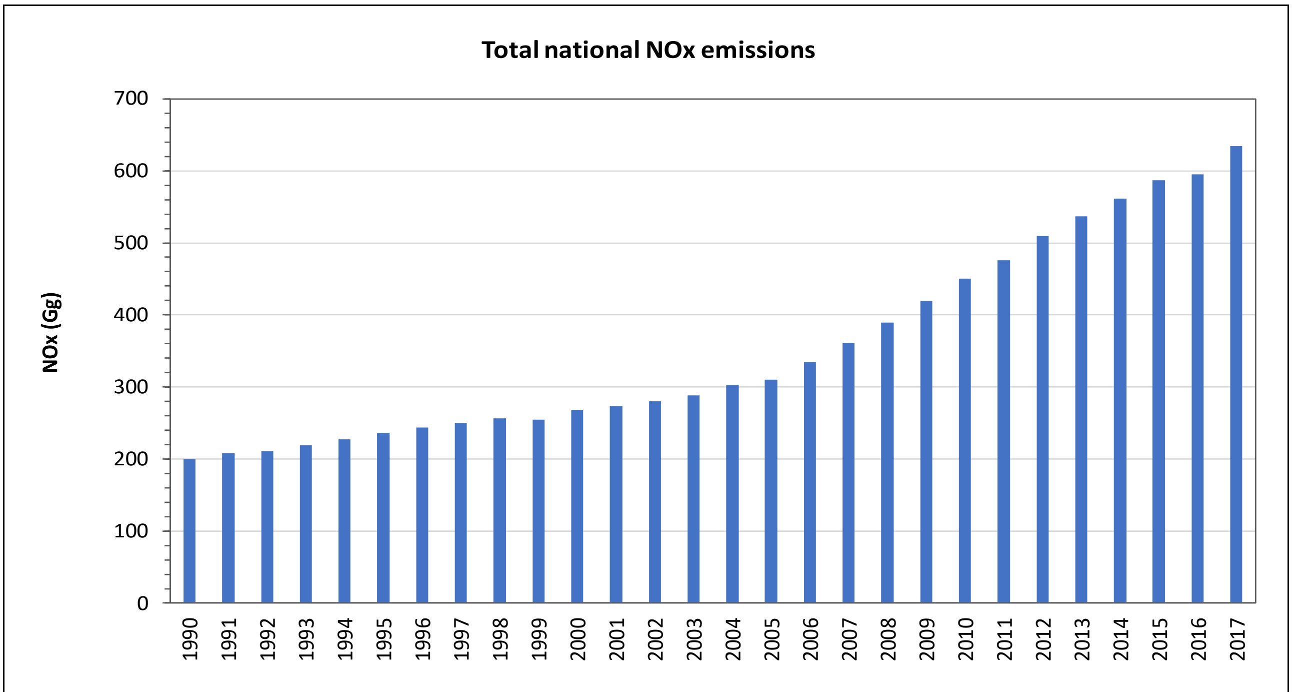


Figure 24 **Total national NOx emissions**

2.1.6 Sulphur Dioxide (SO_2)

Sulphur dioxide (SO_2) emissions arise during the burning of fossil fuels in power stations and other boilers. Sulphur dioxide is created because sulphur is an impurity in most coal and oils. When the fuel is burned the hot sulphur reacts with oxygen in the atmosphere to form sulphur dioxide.

SO_2 emissions increased strongly by 245% from 1990 to 2017. In absolute figures, SO_2 emissions increased from 173.38 Gg to 597.94 Gg during the period from 1990 to 2017 mainly due to higher SO_2 emissions from sub-category 1.A.4 Other Sectors (households).

During the period from 2005 to 2017 SO_2 emissions increased from 275.32 Gg to 597.94 Gg. In 2017, SO_2 emissions were 117% above the level of 2005, mainly due to increasing emissions from the category 1-A.4 Other sectors (households).

Between 2016 and 2017, SO_2 emissions continued to increase by 8,27%. The category 1.A,4 Other Sectors (households) have a share of 90.8% in total SO2 emissions, followed by emissions from the category 1.A.2 Manufacturing Industries and Construction with a share of 9.0%.

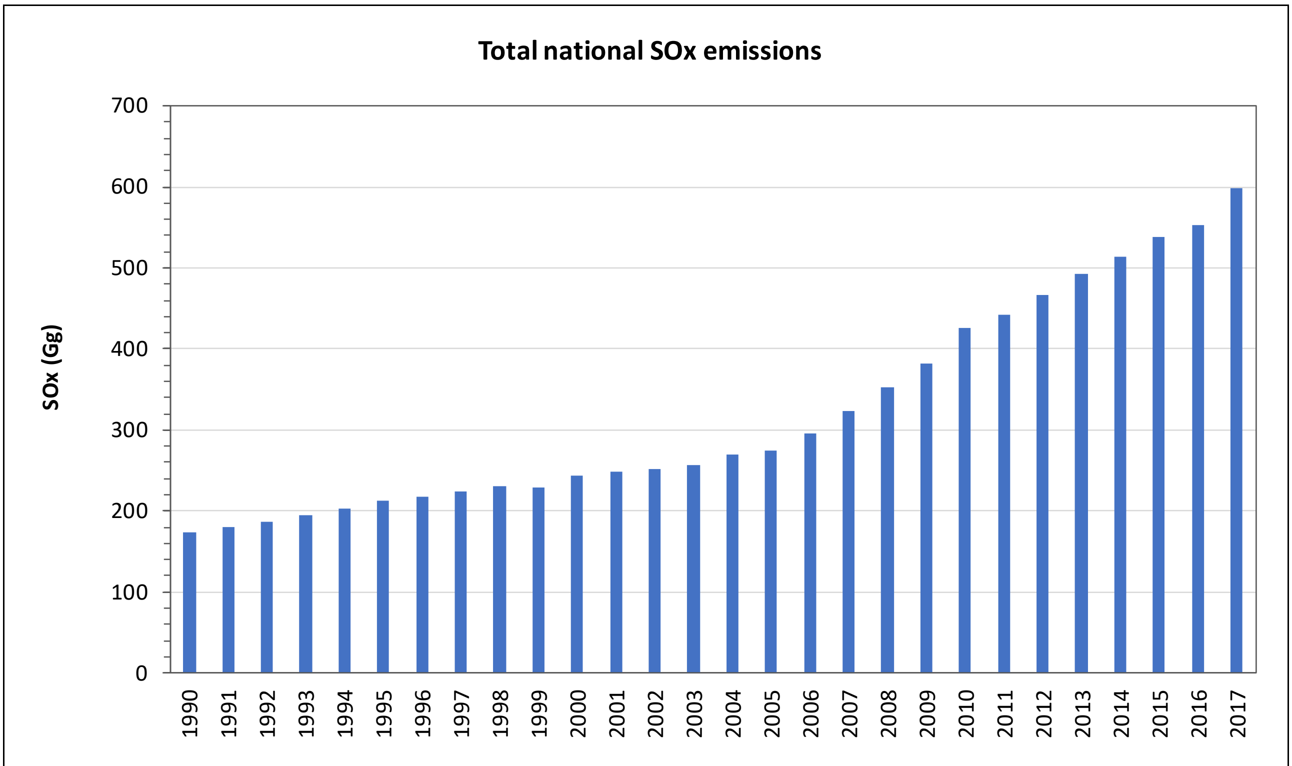


Figure 25 **Total national SOx emissions**

2.1.7 Non-Methane Volatile Organic Compounds (NMVOCs)

Non-Methane Volatile Organic Compounds (NMVOCs) are mainly emitted from transportation, industrial processes and use of organic solvents, which are contained for e.g. in paints, lacquers, varnishes, adhesives, cleaning/degreasing products, pharmaceutical products, printing inks, agricultural products, and plastics.

NMVOC emissions show an increasing trend of 81 %, resulting in 128.42 Gg in 2017 compared to 70.99 Gg in 1990. The increase was mainly driven by emissions from category 1.A.3 Transport.

During the period from 2005 to 2017 NMVOC emissions increased from 77.18 Gg to 128.42 Gg. In 2017, NMVOC emissions were 66% above the level of 2005, mainly caused by emissions from transport.

Between 2016 and 2017, NMVOC emissions show an increasing trend of 2%. The main contributing categories to total NMVOC emissions in 2017 are 1.A.3 Transport (share of 35.0%), 3.D Agricultural Soils and 1.A.4 Other Sectors (households) (share of 24.5%). NMVOC emissions from 3.D Agricultural Soils have kept relatively stable over the whole time series, while the two other most important categories showed significant increases.

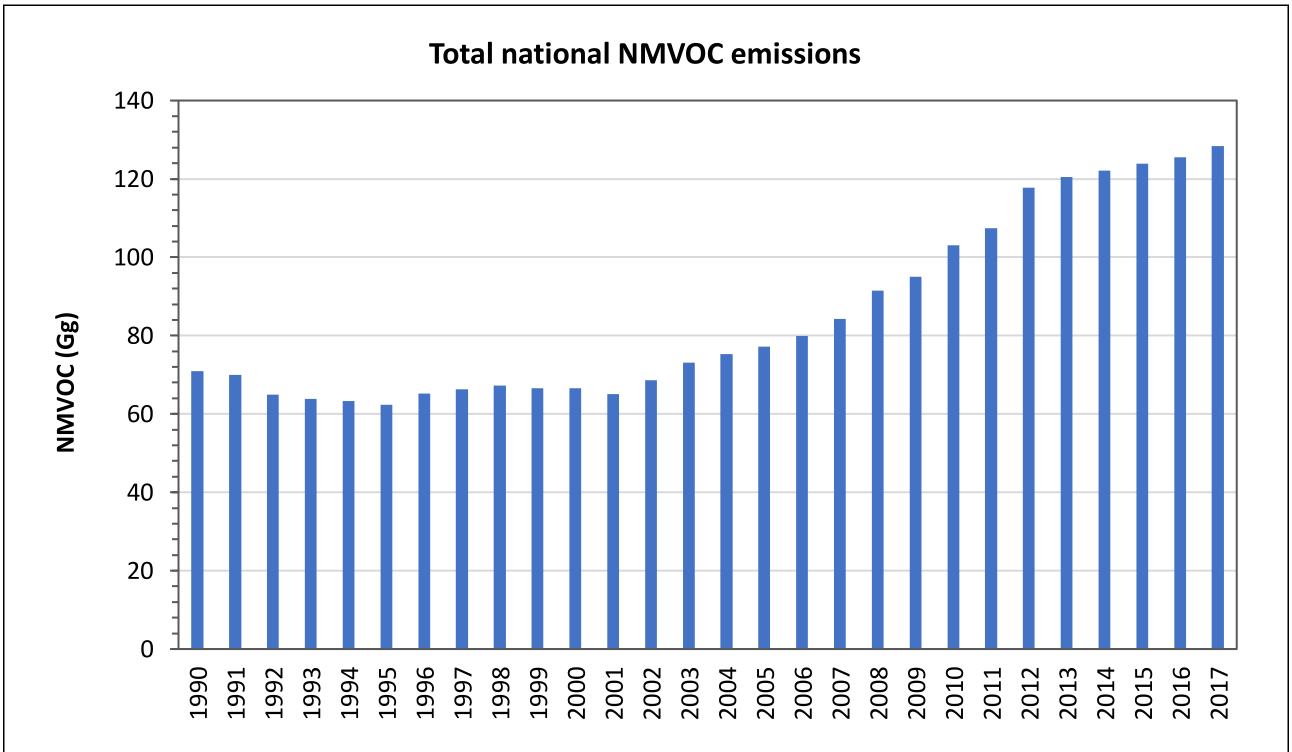


Figure 26 **Total national NMVOC emissions**

Table 35 National GHG inventory of anthropogenic emissions by sources and removals by sinks for 2017

Greenhouse gas source and sink categories	GHG	CO_2 emissions	CO_2 removals	CH_4	N_2O	CO	NO_x	NMVOC	SO_2
	CO_2 Gg *eq*	Gg							
1. Energy	**21,649.43**	**20,615.03**	**NA**	**30.96**	**0.87**	**820.40**	**625.38**	**89.10**	**597.80**
A. Fuel combustion (sectoral approach)	21,593.37	20,603.33	NA	29.18	0.87	820.40	625.38	88.67	597.80
1. Energy industries	408.05	93.30	NA	12.59	0.00	28.27	0.10	6.86	0.14
2. Manufacturing industries and construction	5,962.76	5,924.39	NA	0.55	0.08	55.95	10.62	5.40	54.00
3. Transport	13,136.61	12,881.00	NA	2.83	0.62	344.83	37.22	44.93	0.51
4. Other sectors	2,085.95	1,704.65	NA	13.21	0.17	391.35	577.44	31.47	543.14
5. Other (please specify)	NE	NE	NA	NE	NE	NE	NE	NE	NE
B. Fugitive emissions from fuels	56.05	11.71	NA	1.77	0.00	NA	NA	0.43	NA
1. Solid fuels	37.27	NA	NA	1.49	NA	NA	NA	NA	NA
2. Oil and natural gas	18.78	11.71	NA	0.28	0.00	NA	NA	0.43	NA
2. Industrial processes and product use	**245.78**	**245.78**	**NA**	**NO**	**NO**	**0.00**	**0.02**	**0.08**	**NE**
A. Mineral products	81.68	81.68	NA	NO	NO	NO	NO	NO	NO
B. Chemical industry	130.67	130.67	NA	NO	NO	0.00	0.02	NO	NO
C. Metal production	NO	NO	NA	NO	NO	NO	NO	NO	NO
D. Other production	33.43	33.43	NA	0.00	0.00	0.00	0.00	0.08	0.00
E. Production of halocarbons and SF6	NO	NO	NA	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NA	NE	NE	NE	NE	NE	NE
G. Other (please specify)	NE	NE	NA	NE	NE	NE	NE	NE	NE
3. Agriculture	**20,073.90**	**67.92**	**NA**	**575.05**	**18.89**	**14.13**	**4.78**	**35.20**	**NA**
A. Enteric fermentation	10,273.23	NA	NA	410.93	NA	NA	NA	NA	NA
B. Manure management	2,183.59	NA	NA	81.83	0.46	NA	1.03	NA	NA
C. Rice cultivation	2,040.57	NA	NA	81.62	NO	NA	NA	NA	NA
D. Agricultural soils	5,487.00	0.00	NA	0.00	18.41	0.00	2.13	35.20	0.00
E. Prescribed burning of savannahs	NA	NA	NA	NO	NO	NO	NO	NO	NA
F. Field burning of agricultural residues	21.60	NA	NA	0.67	0.02	14.13	0.58	NA	NA
G. Other (urea application)	67.92	67.92	NA	0.00	0.00	0.00	0.00	0.00	0.00
4. Land-use change and forestry	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5. Waste	**1,502.27**	**6.25**	**NA**	**50.73**	**0.76**	**69.43**	**3.95**	**4.04**	**0.14**
A. Solid waste disposal on land	216.36	0.00	NA	8.65	0.00	NA	NA	2.51	NA
B. Other - Composting	54.13	NA	NA	1.26	0.08	NE	NE	NE	NE
C. Waste incineration	28.87	6.25	NA	0.07	0.07	69.43	3.95	1.53	0.14
D. Waste-water handling	1,202.92	NA	NA	40.74	0.62	NA	NA	NA	NA
6. Other	**NO**	**NO**	**NA**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total national emissions and removals	**43,471.39**	**20,934.98**	**NE**	**656.74**	**20.53**	**903.96**	**634.13**	**128.42**	**597.94**
Memo items									
International bunkers	**31.69**	**31.53**	**NA**	**0.00**	**0.00**	**NE**	**0.11**	**NE**	**NE**
Aviation	31.69	31.53	NA	0.00	0.00	NE	0.11	NE	NE
Marine	NO	NO	NA	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**4,230.35**	**4,230.35**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Table 36 National GHG inventory of anthropogenic emissions by sources and removals by sinks for 2016

Greenhouse gas source and sink categories	GHG	CO_2 emissions	CO_2 removals	CH_4	N_2O	CO	NO_x	NMVOC	SO_2
	CO_2 Gg *eq*	Gg							
1. Energy	**20,664.69**	**19,692.65**	NA	**28.70**	**0.85**	**793.72**	**586.54**	**87.37**	**552.12**
A. Fuel combustion (sectoral approach)	20,609.17	19,680.58	NA	26.96	0.85	793.72	586.54	86.94	552.12
1. Energy industries	336.20	72.41	NA	10.55	0.00	27.50	0.07	6.68	0.06
2. Manufacturing industries and construction	4,816.94	4,787.07	NA	0.43	0.06	44.57	8.53	4.32	42.99
3. Transport	13,136.61	12,881.00	NA	2.83	0.62	344.83	37.22	44.93	0.51
4. Other sectors	2,319.42	1,940.11	NA	13.15	0.17	376.82	540.72	31.00	508.56
5. Other (please specify)	NE	NE	NA	NE	NE	NE	NE	NE	NE
B. Fugitive emissions from fuels	55.52	12.07	NA	1.74	0.00	NA	NA	0.43	NA
1. Solid fuels	36.20	NA	NA	1.45	NA	NA	NA	NA	NA
2. Oil and natural gas	19.33	12.07	NA	0.29	0.00	NA	NA	0.43	NA
2. Industrial processes and product use	**278.59**	**278.59**	NA	**NO**	**NO**	**0.00**	**0.02**	**0.05**	**NE**
A. Mineral products	125.82	125.82	NA	NO	NO	NO	NO	NO	NO
B. Chemical industry	119.33	119.33	NA	NO	NO	0.00	0.02	NO	NO
C. Metal production	NO	NO	NA	NO	NO	NO	NO	NO	NO
D. Other production	33.43	33.43	NA	0.00	0.00	0.00	0.00	0.05	0.00
E. Production of halocarbons and SF6	NO	NO	NA	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NA	NE	NE	NE	NE	NE	NE
G. Other (please specify)	NE	NE	NA	NE	NE	NE	NE	NE	NE
3. Agriculture	**20,490.89**	**67.92**	NA	**574.74**	**20.32**	**15.24**	**4.80**	**34.45**	**NA**
A. Enteric fermentation	10,265.21	NA	NA	410.61	NA	NA	NA	NA	NA
B. Manure management	2,182.39	NA	NA	81.79	0.46	NA	1.03	NA	NA
C. Rice cultivation	2,040.57	NA	NA	81.62	NO	NA	NA	NA	NA
D. Agricultural soils	5,911.65	0.00	NA	0.00	19.84	0.00	2.13	34.45	0.00
E. Prescribed burning of savannahs	NA	NA	NA	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	23.16	NA	NA	0.73	0.02	15.24	0.61	NA	NA
G. Other (urea application)	67.92	67.92	NA	0.00	0.00	0.00	0.00	0.00	0.00
4. Land-use change and forestry	**NE**	**NE**	NE	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5. Waste	**1,446.59**	**6.22**	NA	**49.06**	**0.72**	**69.17**	**3.94**	**3.69**	**0.14**
A. Solid waste disposal on land	197.11	0.00	NA	7.88	0.00	NA	NA	2.17	NA
B. Other - Composting	51.49	NA	NA	1.20	0.07	NE	NE	NE	NE
C. Waste incineration	28.76	6.22	NA	0.07	0.07	69.17	3.94	1.52	0.14
D. Waste-water handling	1,169.23	NA	NA	39.91	0.58	NA	NA	NA	NA
6. Other	**NO**	**NO**	NA	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total national emissions and removals	**42,880.77**	**20,045.39**	NE	**652.50**	**21.89**	**878.14**	**595.30**	**125.55**	**552.25**
Memo items									
International bunkers	**31.69**	**31.53**	NA	**0.00**	**0.00**	**NE**	**0.11**	**NE**	**NE**
Aviation	31.69	31.53	NA	0.00	0.00	NE	0.11	NE	NE
Marine	NO	NO	NA	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**4,218.94**	**4,218.94**	NA	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Table 37 National GHG inventory of anthropogenic emissions by sources and removals by sinks for 2015

Greenhouse gas source and sink categories	GHG	CO_2 emissions	CO_2 removals	CH_4	N_2O	CO	NO_x	NMVOC	SO_2
	CO_2 Gg *eq*	Gg							
1. Energy	**19,614.68**	**18,685.63**	NA	**27.18**	**0.84**	**780.31**	**578.14**	**86.12**	**538.59**
A. Fuel combustion (sectoral approach)	19,561.77	18,674.95	NA	25.49	0.84	780.31	578.14	85.66	538.59
1. Energy industries	292.41	63.78	NA	9.14	0.00	26.75	0.07	6.50	0.06
2. Manufacturing industries and construction	4,040.48	4,016.18	NA	0.35	0.05	37.14	7.14	3.61	35.81
3. Transport	13,015.30	12,761.96	NA	2.81	0.61	341.58	36.89	44.52	0.50
4. Other sectors	2,213.58	1,833.02	NA	13.19	0.17	374.84	534.04	31.03	502.21
5. Other (please specify)	NE	NE	NA	NE	NE	NE	NE	NE	NE
B. Fugitive emissions from fuels	52.91	10.68	NA	1.69	0.00	NA	NA	0.47	NA
1. Solid fuels	35.51	NA	NA	1.42	NA	NA	NA	NA	NA
2. Oil and natural gas	17.40	10.68	NA	0.27	0.00	NA	NA	0.47	NA
2. Industrial processes and product use	**233.87**	**233.87**	NA	**NO**	**NO**	**0.00**	**0.02**	**0.08**	**NE**
A. Mineral products	99.92	99.92	NA	NO	NO	NO	NO	NO	NO
B. Chemical industry	100.51	100.51	NA	NO	NO	0.00	0.02	NO	NO
C. Metal production	NO	NO	NA	NO	NO	NO	NO	NO	NO
D. Other production	33.43	33.43	NA	0.00	0.00	0.00	0.00	0.08	0.00
E. Production of halocarbons and SF6	NO	NO	NA	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NA	NE	NE	NE	NE	NE	NE
G. Other (please specify)	NE	NE	NA	NE	NE	NE	NE	NE	NE
3. Agriculture	**20,729.34**	**67.92**	NA	**576.75**	**20.95**	**15.75**	**4.82**	**34.20**	**NA**
A. Enteric fermentation	10,309.18	NA	NA	412.37	NA	NA	NA	NA	NA
B. Manure management	2,188.64	NA	NA	82.01	0.46	NA	1.03	NA	NA
C. Rice cultivation	2,040.57	NA	NA	81.62	NO	NA	NA	NA	NA
D. Agricultural soils	6,099.17	0.00	NA	0.00	20.47	0.00	2.13	34.20	0.00
E. Prescribed burning of savannahs	NA	NA	NA	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	23.87	NA	NA	0.75	0.02	15.75	0.62	NA	NA
G. Other (urea application)	67.92	67.92	NA	0.00	0.00	0.00	0.00	0.00	0.00
4. Land-use change and forestry	**NE**	**NE**	NE	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5. Waste	**1,417.30**	**6.53**	NA	**47.97**	**0.71**	**72.61**	**4.14**	**3.44**	**0.14**
A. Solid waste disposal on land	180.36	0.00	NA	7.21	0.00	NA	NA	1.84	NA
B. Other - Composting	51.76	NA	NA	1.21	0.07	NE	NE	NE	NE
C. Waste incineration	30.19	6.53	NA	0.08	0.07	72.61	4.14	1.60	0.14
D. Waste-water handling	1,154.99	NA	NA	39.47	0.56	NA	NA	NA	NA
6. Other	**NO**	**NO**	NA	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total national emissions and removals	**41,995.19**	**18,993.95**	NE	**651.91**	**22.50**	**868.68**	**587.11**	**123.84**	**538.73**
Memo items									
International bunkers	**31.38**	**31.22**	NA	**0.00**	**0.00**	**NE**	**0.11**	**NE**	**NE**
Aviation	31.38	31.22	NA	0.00	0.00	NE	0.11	NE	NE
Marine	NO	NO	NA	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**4,234.56**	**4,234.56**	NA	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Table 38 National GHG inventory of anthropogenic emissions by sources and removals by sinks for 2012

Greenhouse gas source and sink categories	GHG	CO_2 emissions	CO_2 removals	CH_4	N_2O	CO	NO_x	NMVOC	SO_2
	CO_2 Gg *eq*	Gg							
1. Energy	**17,324.81**	**16,443.91**	**NA**	**25.81**	**0.79**	**723.04**	**500.83**	**81.42**	**467.08**
A. Fuel combustion (sectoral approach)	17,270.70	16,432.20	NA	24.12	0.79	723.04	500.83	81.02	467.08
1. Energy industries	301.92	93.97	NA	8.31	0.00	24.58	0.10	5.97	0.06
2. Manufacturing industries and construction	4,040.54	4,016.52	NA	0.35	0.05	36.87	7.13	3.59	35.54
3. Transport	12,156.56	11,919.48	NA	2.65	0.57	319.18	34.49	41.64	0.47
4. Other sectors	771.67	402.23	NA	12.81	0.17	342.40	459.13	29.82	431.01
5. Other (please specify)	NE	NE	NA	NE	NE	NE	NE	NE	NE
B. Fugitive emissions from fuels	54.11	11.70	NA	1.70	0.00	NA	NA	0.40	NA
1. Solid fuels	35.43	NA	NA	1.42	NA	NA	NA	NA	NA
2. Oil and natural gas	18.68	11.70	NA	0.28	0.00	NA	NA	0.40	NA
2. Industrial processes and product use	**260.30**	**260.30**	**NA**	**NO**	**NO**	**0.00**	**0.02**	**0.09**	**NE**
A. Mineral products	126.82	126.82	NA	NO	NO	NO	NO	NO	NO
B. Chemical industry	100.04	100.04	NA	NO	NO	0.00	0.02	NO	NO
C. Metal production	NO	NO	NA	NO	NO	NO	NO	NO	NO
D. Other production	33.43	33.43	NA	0.00	0.00	0.00	0.00	0.09	0.00
E. Production of halocarbons and SF6	NO	NO	NA	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NA	NE	NE	NE	NE	NE	NE
G. Other (please specify)	NE	NE	NA	NE	NE	NE	NE	NE	NE
3. Agriculture	**21,06.13**	**60.22**	**NA**	**573.48**	**22.18**	**15.34**	**4.56**	**33.82**	**NA**
A. Enteric fermentation	10,194.85	NA	NA	407.79	NA	NA	NA	NA	NA
B. Manure management	2,360.80	NA	NA	88.90	0.46	NA	1.08	NA	NA
C. Rice cultivation	1,901.44	NA	NA	76.06	NO	NA	NA	NA	NA
D. Agricultural soils	6,466.34	0.00	NA	0.00	21.70	0.00	1.89	33.82	0.00
E. Prescribed burning of savannahs	NA	NA	NA	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	22.48	NA	NA	0.73	0.01	15.34	0.51	NA	NA
G. Other (urea application)	60.22	60.22	NA	0.00	0.00	0.00	0.00	0.00	0.00
4. Land-use change and forestry	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5. Waste	**1,333.39**	**6.56**	**NA**	**45.09**	**0.67**	**72.95**	**4.16**	**2.48**	**0.14**
A. Solid waste disposal on land	147.49	0.00	NA	5.90	0.00	NA	NA	0.87	NA
B. Other - Composting	46.70	NA	NA	1.09	0.07	NE	NE	NE	NE
C. Waste incineration	30.33	6.56	NA	0.08	0.07	72.95	4.16	1.61	0.14
D. Waste-water handling	1,108.86	NA	NA	38.03	0.53	NA	NA	NA	NA
6. Other	**NO**	**NO**	**NA**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total national emissions and removals	**39,924.62**	**16,770.99**	**NE**	**644.39**	**23.64**	**811.33**	**509.57**	**117.82**	**467.23**
Memo items									
International bunkers	**31.69**	**31.53**	**NA**	**0.00**	**0.00**	**NE**	**0.11**	**NE**	**NE**
Aviation	31.69	31.53	NA	0.00	0.00	NE	0.11	NE	NE
Marine	NO	NO	NA	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**4,218.94**	**4,218.94**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Table 39 National GHG inventory of anthropogenic emissions by sources and removals by sinks for 2005

Greenhouse gas source and sink categories	GHG	CO_2 emissions	CO_2 removals	CH_4	N_2O	CO	NO_x	NMVOC	SO_2
	CO_2 Gg *eq*	Gg							
1. Energy	**5,066.98**	**4,587.71**	**NA**	**15.25**	**0.33**	**368.12**	**304.87**	**41.35**	**275.22**
A. Fuel combustion (sectoral approach)	5,014.71	4,574.83	NA	13.68	0.33	368.12	304.87	41.15	275.22
1. Energy industries	200.44	128.76	NA	2.85	0.00	19.98	0.14	4.85	0.10
2. Manufacturing industries and construction	281.90	281.50	NA	0.01	0.00	0.43	0.58	0.13	0.30
3. Transport	4,027.38	3,951.73	NA	0.69	0.20	102.47	11.09	13.11	0.16
4. Other sectors	504.99	212.84	NA	10.13	0.13	245.24	293.06	23.07	274.66
5. Other (please specify)	NE	NE	NA	NE	NE	NE	NE	NE	NE
B. Fugitive emissions from fuels	52.27	12.88	NA	1.58	0.00	NA	NA	0.20	NA
1. Solid fuels	32.57	NA	NA	1.30	NA	NA	NA	NA	NA
2. Oil and natural gas	19.70	12.88	NA	0.27	0.00	NA	NA	0.20	NA
2. Industrial processes and product use	**163.84**	**163.84**	**NA**	**NO**	**NO**	**0.00**	**0.02**	**0.12**	**NE**
A. Mineral products	6.21	6.21	NA	NO	NO	NO	NO	NO	NO
B. Chemical industry	124.19	124.19	NA	NO	NO	0.00	0.02	NO	NO
C. Metal production	NO	NO	NA	NO	NO	NO	NO	NO	NO
D. Other production	33.43	33.43	NA	0.00	0.00	0.00	0.00	0.12	0.00
E. Production of halocarbons and SF6	NO	NO	NA	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NA	NE	NE	NE	NE	NE	NE
G. Other (please specify)	NE	NE	NA	NE	NE	NE	NE	NE	NE
3. Agriculture	**16,036.89**	**18.40**	**NA**	**434.33**	**17.32**	**12.57**	**2.50**	**34.33**	**NA**
A. Enteric fermentation	7814.80	NA	NA	312.59	NA	NA	NA	NA	NA
B. Manure management	1656.99	NA	NA	61.78	0.38	NA	0.76	NA	NA
C. Rice cultivation	1484.05	NA	NA	59.36	NO	NA	NA	NA	NA
D. Agricultural soils	5044.38	0.00	NA	0.00	16.93	0.00	0.58	34.33	0.00
E. Prescribed burning of savannahs	NA	NA	NA	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	18.27	NA	NA	0.60	0.01	12.57	0.40	NA	NA
G. Other (urea application)	18.40	18.40	NA	0.00	0.00	0.00	0.00	0.00	0.00
4. Land-use change and forestry	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5. Waste	**1,186.15**	**4.63**	**NA**	**40.64**	**0.56**	**51.43**	**2.93**	**1.37**	**0.10**
A. Solid waste disposal on land	129.79	0.00	NA	5.19	0.00	NA	NA	0.24	NA
B. Other - Composting	31.11	NA	NA	0.73	0.04	NE	NE	NE	NE
C. Waste incineration	21.38	4.63	NA	0.06	0.05	51.43	2.93	1.13	0.10
D. Waste-water handling	1,003.87	NA	NA	34.67	0.46	NA	NA	NA	NA
6. Other	**NO**	**NO**	**NA**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total national emissions and removals	**22,453.86**	**4,774.58**	**NE**	**490.22**	**18.20**	**432.12**	**310.32**	**77.18**	**275.32**
Memo items									
International bunkers	**31.69**	**31.53**	**NA**	**0.00**	**0.00**	**NE**	**0.11**	**NE**	**NE**
Aviation	31.69	31.53	NA	0.00	0.00	NE	0.11	NE	NE
Marine	NO	NO	NA	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**3,341.17**	**3,341.17**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Table 40 National GHG inventory of anthropogenic emissions by sources and removals by sinks for 1990

Greenhouse gas source and sink categories	GHG	CO_2 emissions	CO_2 removals	CH_4	N_2O	CO	NO_x	NMVOC	SO_2
	CO_2 Gg *eq*	Gg							
1. Energy	**5,267.65**	**4,886.21**	**NA**	**11.55**	**0.31**	**284.74**	**196.48**	**33.06**	**173.32**
A. Fuel combustion (sectoral approach)	5,211.22	4,870.53	NA	9.92	0.31	284.74	196.48	32.89	173.32
1. Energy industries	74.65	45.74	NA	1.15	0.00	8.06	0.06	1.96	0.10
2. Manufacturing industries and construction	538.80	536.90	NA	0.03	0.00	1.87	1.51	0.30	1.66
3. Transport	4,190.11	4,114.52	NA	0.64	0.20	98.96	11.71	12.82	0.20
4. Other sectors	407.66	173.37	NA	8.10	0.11	175.84	183.21	17.82	171.35
5. Other (please specify)	NE	NE	NA	NE	NE	NE	NE	NE	NE
B. Fugitive emissions from fuels	56.43	15.67	NA	1.63	0.00	NA	NA	0.17	NA
1. Solid fuels	32.73	NA	NA	1.31	NA	NA	NA	NA	NA
2. Oil and natural gas	23.70	15.67	NA	0.32	0.00	NA	NA	0.17	NA
2. Industrial processes and product use	**248.13**	**248.13**	**NA**	**NO**	**NO**	**0.00**	**0.02**	**0.12**	**NE**
A. Mineral products	45.77	45.77	NA	NO	NO	NO	NO	NO	NO
B. Chemical industry	168.93	168.93	NA	NO	NO	0.00	0.02	NO	NO
C. Metal production	NO	NO	NA	NO	NO	NO	NO	NO	NO
D. Other production	33.43	33.43	NA	0.00	0.00	0.00	0.00	0.12	0.00
E. Production of halocarbons and SF6	NO	NO	NA	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NA	NE	NE	NE	NE	NE	NE
G. Other (please specify)	NE	NE	NA	NE	NE	NE	NE	NE	NE
3. Agriculture	**11,623.10**	**53.73**	**NA**	**338.05**	**10.46**	**5.98**	**1.90**	**36.75**	**NA**
A. Enteric fermentation	4,976.19	NA	NA	199.05	NA	NA	NA	NA	NA
B. Manure management	1,940.87	NA	NA	73.79	0.32	NA	NA	NA	NA
C. Rice cultivation	1,623.18	NA	NA	64.93	NO	NA	NA	NA	NA
D. Agricultural soils	3,020.26	0.00	NA	0.00	10.14	0.00	1.69	36.75	0.00
E. Prescribed burning of savannahs	NA	NA	NA	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	8.87	NA	NA	0.28	0.01	5.98	0.21	NA	NA
G. Other (urea application)	53.73	53.73	NA	0.00	0.00	0.00	0.00	0.00	0.00
4. Land-use change and forestry	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5. Waste	**937.70**	**3.03**	**NA**	**32.77**	**0.39**	**33.68**	**1.92**	**1.05**	**0.07**
A. Solid waste disposal on land	131.72	0.00	NA	5.27	0.00	NA	NA	0.31	NA
B. Other - Composting	20.27	NA	NA	0.47	0.03	NE	NE	NE	NE
C. Waste incineration	14.00	3.03	NA	0.04	0.03	33.68	1.92	0.74	0.07
D. Waste-water handling	771.72	NA	NA	26.99	0.33	NA	NA	NA	NA
6. Other	**NO**	**NO**	**NA**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total national emissions and removals	**18,076.57**	**5,191.09**	**NE**	**382.37**	**11.16**	**324.39**	**200.32**	**70.99**	**173.38**
Memo items									
International bunkers	**19.08**	**18.92**	**NA**	**0.00**	**0.00**	**NE**	**0.07**	**NE**	**NE**
Aviation	19.08	18.92	NA	0.00	0.00	NE	0.07	NE	NE
Marine	NO	NO	NA	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**2,648.29**	**2,648.29**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

2.2 Emission trend by sector

2.8.1. Description and interpretation of emission trends by Sectors

The important sectors regarding GHG emissions in Afghanistan excluding LULUCF are IPCC sector 1 Energy with 49.8% of total national GHG emissions in 2017 (29.1% in 1990), followed by the IPCC sectors 3 Agriculture with 46.2% of total national GHG emissions in 2017 (64.3% in 1990). The following figure and table present a summary of Afghanistan's anthropogenic greenhouse gas emissions by sector.

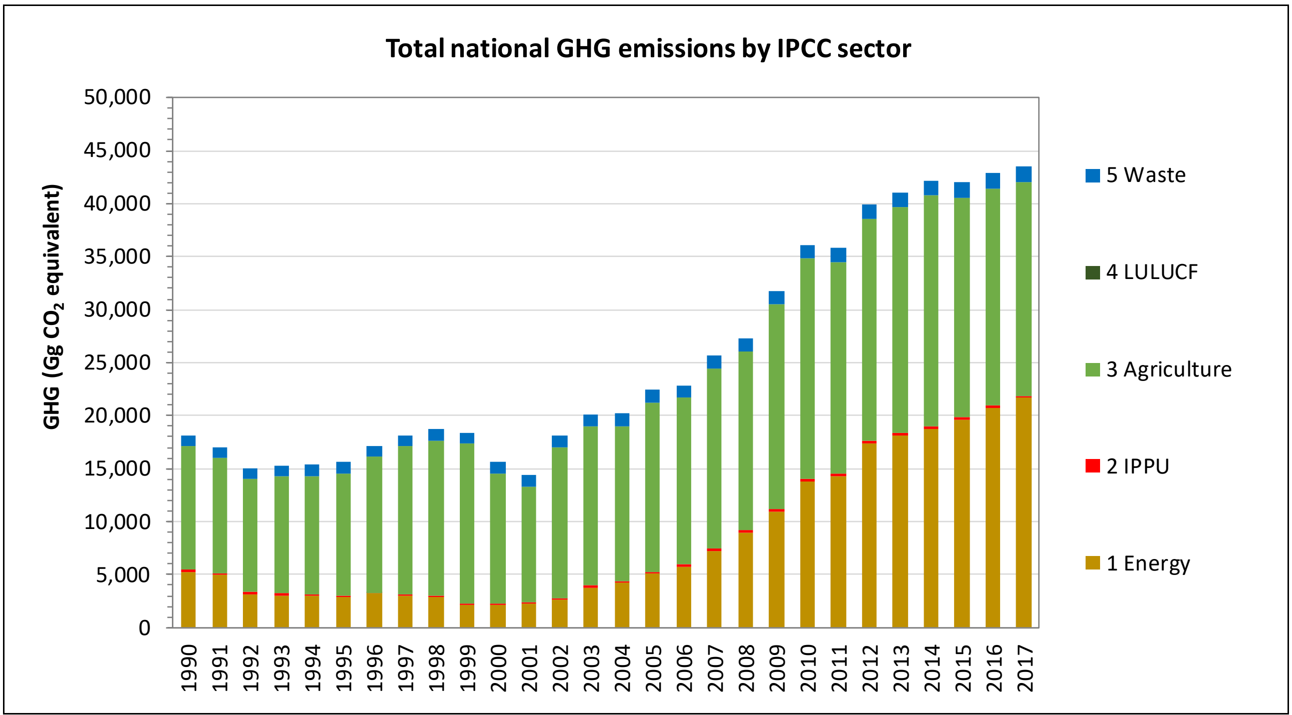


Figure 27 **Total national GHG emissions in GHG equivalent by IPCC sector**

In 2017, greenhouse gas emissions from IPCC sector Energy amounted to 21,649.43 Gg CO_2 equivalents which correspond to about 50% of the total national emissions. Some 99% of the emissions from this sector, originate from IPCC category 1.A. Fossil Fuel Combustion. IPCC category 1.B Fugitive Emissions from fuels are of minor importance. From 1990 to 2017, emissions from this sector increased by 140%, from 2005 to 2017, emissions from this sector increased by 94%, and from 2016 to 2017, emissions from this sector increased by only 1%. The main increase occurred in the transport sector and by Manufacturing Industries and Construction due to higher consumption of fossil fuels.

In 2017, greenhouse gas emissions from IPCC sector Industrial Processes and Other Product Use (IPPU) amounted to 245.78 Gg CO_2 equivalents, which correspond to 0.6% of the total national emissions. From 1990 to 2017, emissions from this sector decreased by 0.9%, from 2005 to 2017, emissions from this sector increased by 50%, mainly due to a decrease in lime production. Between 2016 and 2017, emissions decreased by 12%, due to a significant decrease in emissions from category 2.A Mineral Industry.

In 2017, greenhouse gas emissions from IPCC sector Agriculture amounted to 20,073.90 Gg CO_2 equivalent, which correspond to about 46.2% of total national emissions. From 1990 to 2017, emissions from this sector increased by 73%, from 2005 to 2017, emissions from this sector increased by 25%, due to increasing emissions in all agricultural emission categories. Between 2016 and 2017 the decreasing emission trend of recent years continued, and resulted in an emission reduction of 2.0%, due to less emissions from category

3.D Agricultural Soils.

In 2017, greenhouse gas emissions from IPCC sector Waste amounted to 1,502.27 Gg CO_2 equivalents, which correspond to 3.5% of total national emissions. From 1990 to 2017, emissions from this sector increased by 60.2%, from 2005 to 2017, emissions from this sector increased by 26.7%. Between 2016 and 2017, emission continued to increase by 3.8%. The increasing trend is due to emission from the category 5.D Wastewater Treatment and Discharge, as well as 5.A Solid waste disposal.

Table 41Summary of Afghanistan's anthropogenic greenhouse gas (GHG) emissions by sector

Greenhouse gas source and sink categories	1990	2000	2005	2010	2015	2016	2017	Trend 1990 – 2017	1990	2017
	Gg CO_2 equivalent								Share [%]	
1. Energy	5,267.65	2,178.63	5,066.98	13,749.13	19,614.68	20,664.69	21,649.43	311%	29%	50%
2. Industrial Processes and Product Use	248.13	58.48	163.84	231.32	248.13	278.59	245.78	-1%	1%	1%
3. Agriculture	11,623.10	12,302.26	16,036.89	20,831.46	11,623.10	20,490.89	20,073.90	73%	64%	46%
4. Land-use change and forestry (LULUCF)	NE	NE	NE	NE	NE	NE	NE			
5. Waste	937.70	1,088.18	1,186.15	1,290.51	937.70	1,446.59	1,502.27	60%	5%	3%
6. Other	NO	NO	NO	NO	NO	NO	NO			
Total national emissions and removals	18,076.57	15,627.54	22,453.86	36,102.42	18,076.57	42,880.77	43,471.39	140.5%	100%	100%

In the following figure the trend of the GHG emissions compared to 1990 by sector is presented. The emission from the sectors Energy and IPPU decreased in the first decade. Whereas the emission of the sector Energy increased significantly compared to 1990, the emissions from IPPU were in 2017 on the level of 1990.The emissions from the sectors Agriculture and Waste increased constantly but are still on a low level.

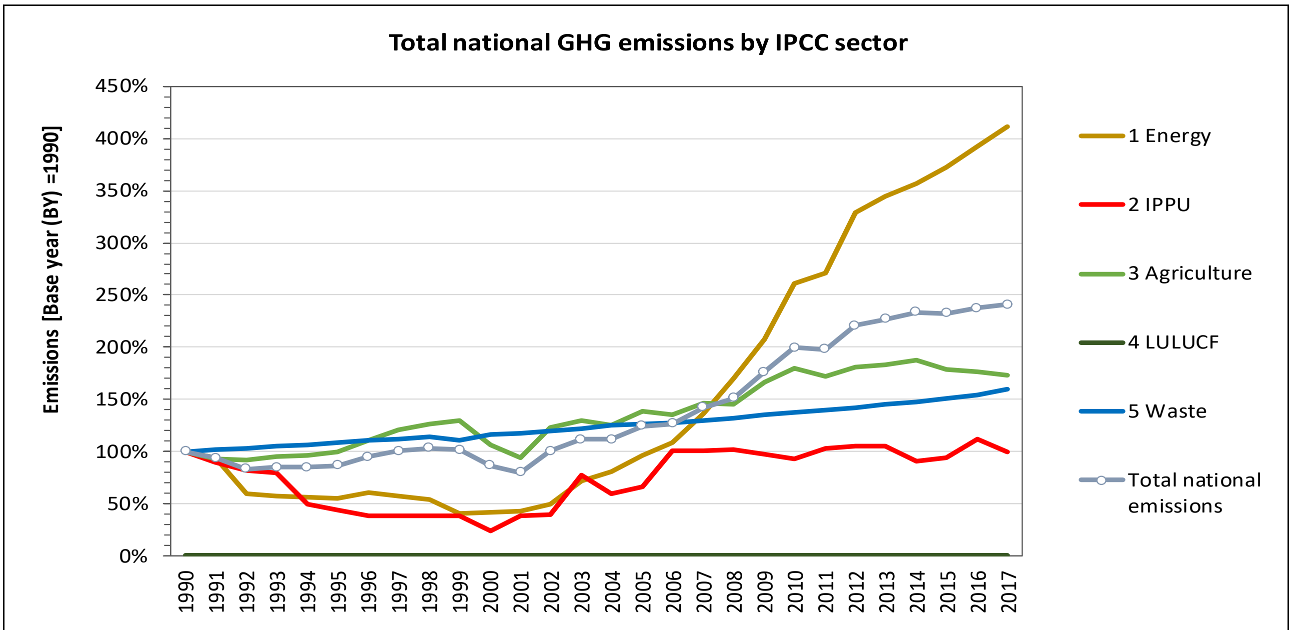


Figure 28 **GHG Emission trend for the period 1990 . 2017 in index form (base year = 100) by IPCC sector**

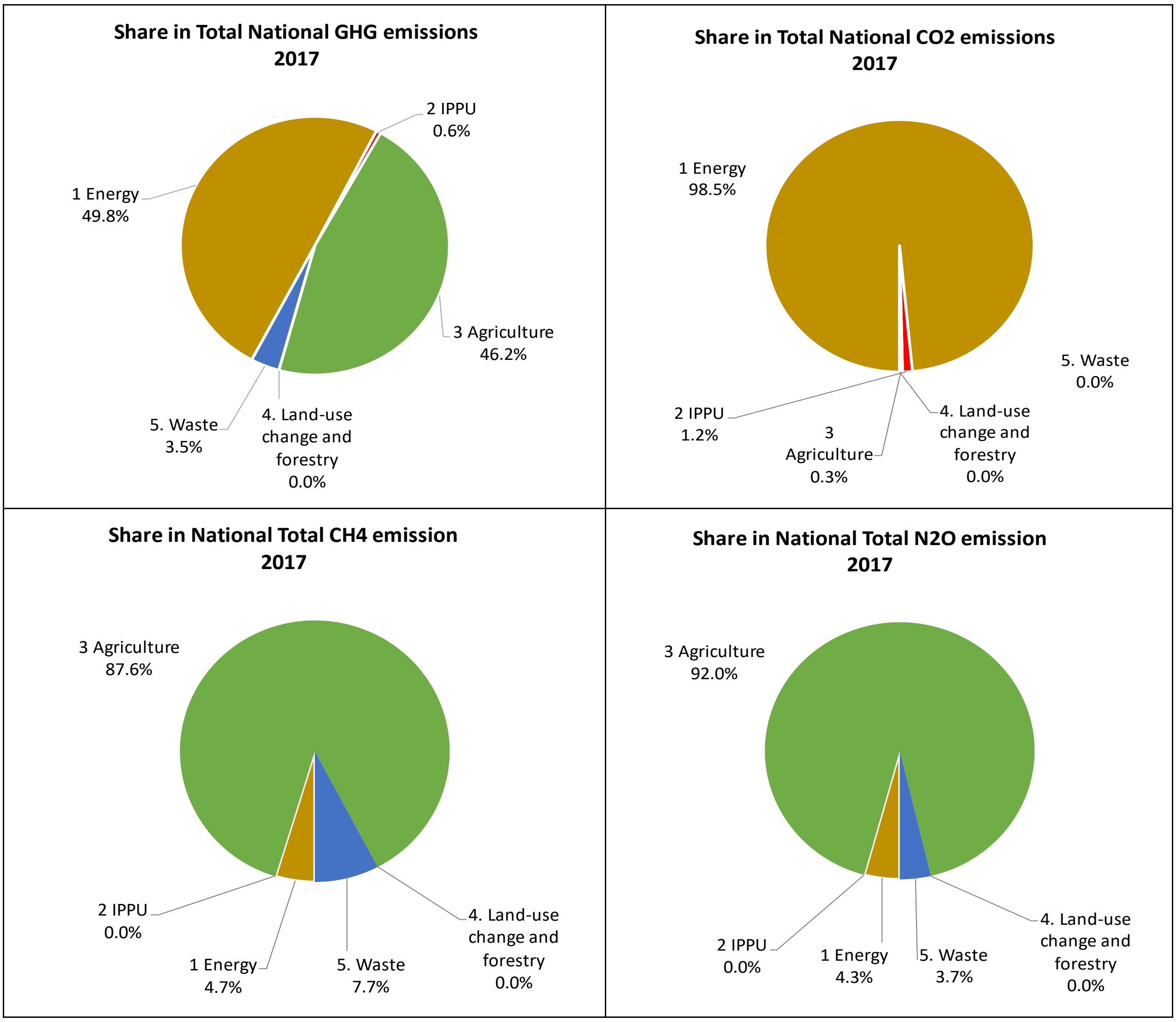


Figure 29 **Share of IPCC sectors in National total GHG, in CO_2, in CH_4 and N_2O emissions for the year 2017**

Table 42 Trend of GHG emissions by sources and removals by sinks for 1990 – 2017.

Greenhouse gas source and sink categories	1990	2000	2005	2010	2012	2015	2016	2017
Carbon dioxide (CO_2)	Gg							
1. Energy	**5,267.65**	**2,178.63**	**5,066.98**	**5,066.98**	**17,324.81**	**19,614.68**	**20,664.69**	**21,649.43**
A. Fuel combustion	5,211.22	2,132.61	5,014.71	5,014.71	17,270.70	19,561.77	20,609.17	21,593.37
1. Energy industries	74.65	67.30	200.44	200.44	301.92	292.41	336.20	408.05
2. Manufacturing industries and construction	538.80	374.35	281.90	281.90	4,040.54	4,040.48	4,816.94	5,962.76
3. Transport	4,190.11	1,289.07	4,027.38	4,027.38	12,156.56	13,015.30	13,136.61	13,136.61
4. Other sectors	407.66	401.89	504.99	504.99	771.67	2,213.58	2,319.42	2,085.95
5. Other	NE	NE	NE	NE	NE	NE	NE	NE
B. Fugitive emissions from fuels	56.43	46.02	52.27	52.27	54.11	52.91	55.52	56.05
1. Solid fuels	32.73	32.50	32.57	32.57	35.43	35.51	36.20	37.27
2. Oil and natural gas	23.70	13.52	19.70	19.70	18.68	17.40	19.33	18.78
2. Industrial Processes and Product Use	**248.13**	**58.48**	**163.84**	**163.84**	**260.30**	**233.87**	**278.59**	**245.78**
A. Mineral products	45.77	10.22	6.21	6.21	126.82	99.92	125.82	81.68
B. Chemical industry	168.93	14.83	124.19	124.19	100.04	100.51	119.33	130.67
C. Metal production	NO	NO	NO	NO	NO	NO	NO	NO
D. Other production	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	NE	NE	NE	NE	NE
G. Other	NE	NE	NE	NE	NE	NE	NE	NE
3. Agriculture	**11,623.10**	**12,302.26**	**16,036.89**	**16,036.89**	**21,006.13**	**20,729.34**	**20,490.89**	**20,073.90**
A. Enteric fermentation	4,976.19	7,097.63	7,814.80	7,814.80	10,194.85	10,309.18	10,265.21	10,273.23
B. Manure management	1,940.87	1,547.33	1,656.99	1,656.99	2,360.80	2,188.64	2,182.39	2,183.59
C. Rice cultivation	1,623.18	1,205.79	1,484.05	1,484.05	1,901.44	2,040.57	2,040.57	2,040.57
D. Agricultural soils	3,020.26	2,439.16	5,044.38	5,044.38	6,466.34	6,099.17	5,911.65	5,487.00
E. Prescribed burning of savannahs	NA	NA	NA	NA	NA	NA	NA	NA
F. Field burning of agricultural residues	8.87	7.67	18.27	18.27	22.48	23.87	23.16	21.60
G. Other	53.73	4.67	18.40	18.40	60.22	67.92	67.92	67.92
4. Land-Use, Land-Use Change and Forestry (LULUCF)	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5. Waste	**937.70**	**1,088.18**	**1,186.15**	**1,186.15**	**1,333.39**	**1,417.30**	**1,446.59**	**1,502.27**
A. Solid waste disposal on land	131.72	130.36	129.79	129.79	147.49	180.36	197.11	216.36
B. Waste-water handling	20.27	28.06	31.11	31.11	46.70	51.76	51.49	54.13
C. Waste incineration	14.00	19.34	21.38	21.38	30.33	30.19	28.76	28.87
D. Other - Composting	771.72	910.42	1,003.87	1,003.87	1,108.86	1,154.99	1,169.23	1,202.92
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total national emissions and removals	**18,076.57**	**15,627.54**	**22,453.86**	**22,453.86**	**39,924.62**	**41,995.19**	**42,880.77**	**43,471.39**
Memo items								
International bunkers	**19.08**	**15.93**	**31.69**	**31.69**	**31.69**	**31.38**	**31.69**	**31.69**
Aviation	19.08	15.93	31.69	31.69	31.69	31.38	31.69	31.69
Marine	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**2,648.29**	**3,091.05**	**3,341.17**	**3,341.17**	**4,168.42**	**4,234.56**	**4,218.94**	**4,230.35**

Table 43 Trend of CO_2 emissions by sources and removals by sinks for 1990 – 2017.

Greenhouse gas source and sink categories	1990	2000	2005	2010	2012	2015	2016	2017
Carbon dioxide (CO_2)	Gg							
1. Energy	**5,267.65**	**2,178.63**	**5,066.98**	**5,066.98**	**17,324.81**	**19,614.68**	**20,664.69**	**21,649.43**
A. Fuel combustion	5,211.22	2,132.61	5,014.71	5,014.71	17,270.70	19,561.77	20,609.17	21,593.37
1. Energy industries	74.65	67.30	200.44	200.44	301.92	292.41	336.20	408.05
2. Manufacturing industries and construction	538.80	374.35	281.90	281.90	4,040.54	4,040.48	4,816.94	5,962.76
3. Transport	4,190.11	1,289.07	4,027.38	4,027.38	12,156.56	13,015.30	13,136.61	13,136.61
4. Other sectors	407.66	401.89	504.99	504.99	771.67	2,213.58	2,319.42	2,085.95
5. Other	NE	NE	NE	NE	NE	NE	NE	NE
B. Fugitive emissions from fuels	56.43	46.02	52.27	52.27	54.11	52.91	55.52	56.05
1. Solid fuels	32.73	32.50	32.57	32.57	35.43	35.51	36.20	37.27
2. Oil and natural gas	23.70	13.52	19.70	19.70	18.68	17.40	19.33	18.78
2. Industrial Processes and Product Use	**248.13**	**58.48**	**163.84**	**163.84**	**260.30**	**233.87**	**278.59**	**245.78**
A. Mineral products	45.77	10.22	6.21	6.21	126.82	99.92	125.82	81.68
B. Chemical industry	168.93	14.83	124.19	124.19	100.04	100.51	119.33	130.67
C. Metal production	NO	NO	NO	NO	NO	NO	NO	NO
D. Other production	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	NE	NE	NE	NE	NE
G. Other	NE	NE	NE	NE	NE	NE	NE	NE
3. Agriculture	**11,623.10**	**12,302.26**	**16,036.89**	**16,036.89**	**21,006.13**	**20,729.34**	**20,490.89**	**20,073.90**
A. Enteric fermentation	4,976.19	7,097.63	7,814.80	7,814.80	10,194.85	10,309.18	10,265.21	10,273.23
B. Manure management	1,940.87	1,547.33	1,656.99	1,656.99	2,360.80	2,188.64	2,182.39	2,183.59
C. Rice cultivation	1,623.18	1,205.79	1,484.05	1,484.05	1,901.44	2,040.57	2,040.57	2,040.57
D. Agricultural soils	3,020.26	2,439.16	5,044.38	5,044.38	6,466.34	6,099.17	5,911.65	5,487.00
E. Prescribed burning of savannahs	NA	NA	NA	NA	NA	NA	NA	NA
F. Field burning of agricultural residues	8.87	7.67	18.27	18.27	22.48	23.87	23.16	21.60
G. Other	53.73	4.67	18.40	18.40	60.22	67.92	67.92	67.92
4. Land-Use, Land-Use Change and Forestry (LULUCF)	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5. Waste	**937.70**	**1,088.18**	**1,186.15**	**1,186.15**	**1,333.39**	**1,417.30**	**1,446.59**	**1,502.27**
A. Solid waste disposal on land	131.72	130.36	129.79	129.79	147.49	180.36	197.11	216.36
B. Waste-water handling	20.27	28.06	31.11	31.11	46.70	51.76	51.49	54.13
C. Waste incineration	14.00	19.34	21.38	21.38	30.33	30.19	28.76	28.87
D. Other - Composting	771.72	910.42	1,003.87	1,003.87	1,108.86	1,154.99	1,169.23	1,202.92
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total national emissions and removals	**18,076.57**	**15,627.54**	**22,453.86**	**22,453.86**	**39,924.62**	**41,995.19**	**42,880.77**	**43,471.39**
Memo items								
International bunkers	**19.08**	**15.93**	**31.69**	**31.69**	**31.69**	**31.38**	**31.69**	**31.69**
Aviation	19.08	15.93	31.69	31.69	31.69	31.38	31.69	31.69
Marine	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**2,648.29**	**3,091.05**	**3,341.17**	**3,341.17**	**4,168.42**	**4,234.56**	**4,218.94**	**4,230.35**

Table 44 Trend of GHG emissions by sources and removals by sinks for 1990 – 2017.

Greenhouse gas source and sink categories	1990	2000	2005	2010	2012	2015	2016	2017
Methane (CH_4)	Gg							
1. Energy	**11.55**	**13.42**	**15.25**	**15.25**	**25.81**	**27.18**	**28.70**	**30.96**
A. Fuel combustion	9.92	11.93	13.68	13.68	24.12	25.49	26.96	29.18
1. Energy industries	1.15	2.38	2.85	2.85	8.31	9.14	10.55	12.59
2. Manufacturing industries and construction	0.03	0.01	0.01	0.01	0.35	0.35	0.43	0.55
3. Transport	0.64	0.16	0.69	0.69	2.65	2.81	2.83	2.83
4. Other sectors	8.10	9.38	10.13	10.13	12.81	13.19	13.15	13.21
5. Other	NE	NE	NE	NE	NE	NE	NE	NE
B. Fugitive emissions from fuels	1.63	1.49	1.58	1.58	1.70	1.69	1.74	1.77
1. Solid fuels	1.31	1.30	1.30	1.30	1.42	1.42	1.45	1.49
2. Oil and natural gas	0.32	0.19	0.27	0.27	0.28	0.27	0.29	0.28
2. Industrial Processes and Product Use	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
A. Mineral products	NO	NO	NO	NO	NO	NO	NO	NO
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal production	NO	NO	NO	NO	NO	NO	NO	NO
D. Other production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	NE	NE	NE	NE	NE
G. Other	NE	NE	NE	NE	NE	NE	NE	NE
3. Agriculture	**338.05**	**389.97**	**434.33**	**434.33**	**573.48**	**576.75**	**574.74**	**575.05**
A. Enteric fermentation	199.05	283.91	312.59	312.59	407.79	412.37	410.61	410.93
B. Manure management	73.79	57.59	61.78	61.78	88.90	82.01	81.79	81.83
C. Rice cultivation	64.93	48.23	59.36	59.36	76.06	81.62	81.62	81.62
D. Agricultural soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Prescribed burning of savannahs	NO	NO	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	0.28	0.24	0.60	0.60	0.73	0.75	0.73	0.67
G. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Land-Use, Land-Use Change and Forestry (LULUCF)	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5. Waste	**32.77**	**38.08**	**40.64**	**40.64**	**45.09**	**47.97**	**49.06**	**50.73**
A. Solid waste disposal on land	5.27	5.21	5.19	5.19	5.90	7.21	7.88	8.65
B. Waste-water handling	0.47	0.65	0.73	0.73	1.09	1.21	1.20	1.26
C. Waste incineration	0.04	0.05	0.06	0.06	0.08	0.08	0.07	0.07
D. Other - Composting	26.99	32.16	34.67	34.67	38.03	39.47	39.91	40.74
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total national emissions and removals	**382.37**	**441.47**	**490.22**	**490.22**	**644.39**	**651.91**	**652.50**	**656.74**
Memo items	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
International bunkers	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marine	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Table 45 Trend of N_2O emissions by sources and removals by sinks for 1990 – 2017.

Greenhouse gas source and sink categories	1990	2000	2005	2010	2012	2015	2016	2017
Nitrous oxide (N_2O)	**Gg**							
1. Energy	**0.31**	**0.18**	**0.33**	**0.33**	**0.79**	**0.84**	**0.85**	**0.87**
A. Fuel combustion	0.31	0.18	0.33	0.33	0.79	0.84	0.85	0.87
1. Energy industries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Manufacturing industries and construction	0.00	0.00	0.00	0.00	0.05	0.05	0.06	0.08
3. Transport	0.20	0.06	0.20	0.20	0.57	0.61	0.62	0.62
4. Other sectors	0.11	0.12	0.13	0.13	0.17	0.17	0.17	0.17
5. Other	NE	NE	NE	NE	NE	NE	NE	NE
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid fuels	NA	NA	NA	NA	NA	NA	NA	NA
2. Oil and natural gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Industrial Processes and Product Use	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
A. Mineral products	NO	NO	NO	NO	NO	NO	NO	NO
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal production	NO	NO	NO	NO	NO	NO	NO	NO
D. Other production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	NE	NE	NE	NE	NE
G. Other	NE	NE	NE	NE	NE	NE	NE	NE
3. Agriculture	**10.46**	**8.55**	**17.32**	**17.32**	**22.18**	**20.95**	**20.32**	**18.89**
A. Enteric fermentation	NA	NA	NA	NA	NA	NA	NA	NA
B. Manure management	0.32	0.36	0.38	0.38	0.46	0.46	0.46	0.46
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	10.14	8.19	16.93	16.93	21.70	20.47	19.84	18.41
E. Prescribed burning of savannahs	NO	NO	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
G. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Land-Use, Land-Use Change and Forestry (LULUCF)	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5. Waste	**0.39**	**0.44**	**0.56**	**0.56**	**0.67**	**0.71**	**0.72**	**0.76**
A. Solid waste disposal on land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B. Waste-water handling	0.03	0.04	0.04	0.04	0.07	0.07	0.07	0.08
C. Waste incineration	0.03	0.05	0.05	0.05	0.07	0.07	0.07	0.07
D. Other - Composting	0.33	0.36	0.46	0.46	0.53	0.56	0.58	0.62
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total national emissions and removals	**11.16**	**9.18**	**18.20**	**18.20**	**23.64**	**22.50**	**21.89**	**20.53**
Memo items								
International bunkers	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marine	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

2.2.1 Energy (IPCC Sector 1)

In the Energy Sector, emissions originating from fuel combustion activities in road traffic, in the energy and manufacturing industry and in the commercial, agricultural and residential sector (Category 1.A) as well as fugitive emissions from fuels (Category 1.B) are considered. However, fugitive emissions make up less than 1% of the total emissions from this sector.

Emissions from the Energy Sector are the main source of GHGs in Afghanistan:

- in 1990 about 29.1% of the total national GHG emissions and 92.8% of total CO_2 emissions arose from the energy sector, whereas N_2O and CH_4 emissions only make up about 1.8% and 5.5%, respectively.
- in 2005 about 22.6% of the total national GHG emissions and 90.5% of total CO_2 emissions arose from the energy sector, whereas N_2O and CH_4 emissions only make up about 1.9% and 7.5%, respectively.
- in 2017 about 49.8% of the total national GHG emissions and 95.2% of total CO_2 emissions arose from the energy sector, whereas N_2O and CH_4 emissions only make up about 1.2% and 3.6%, respectively.

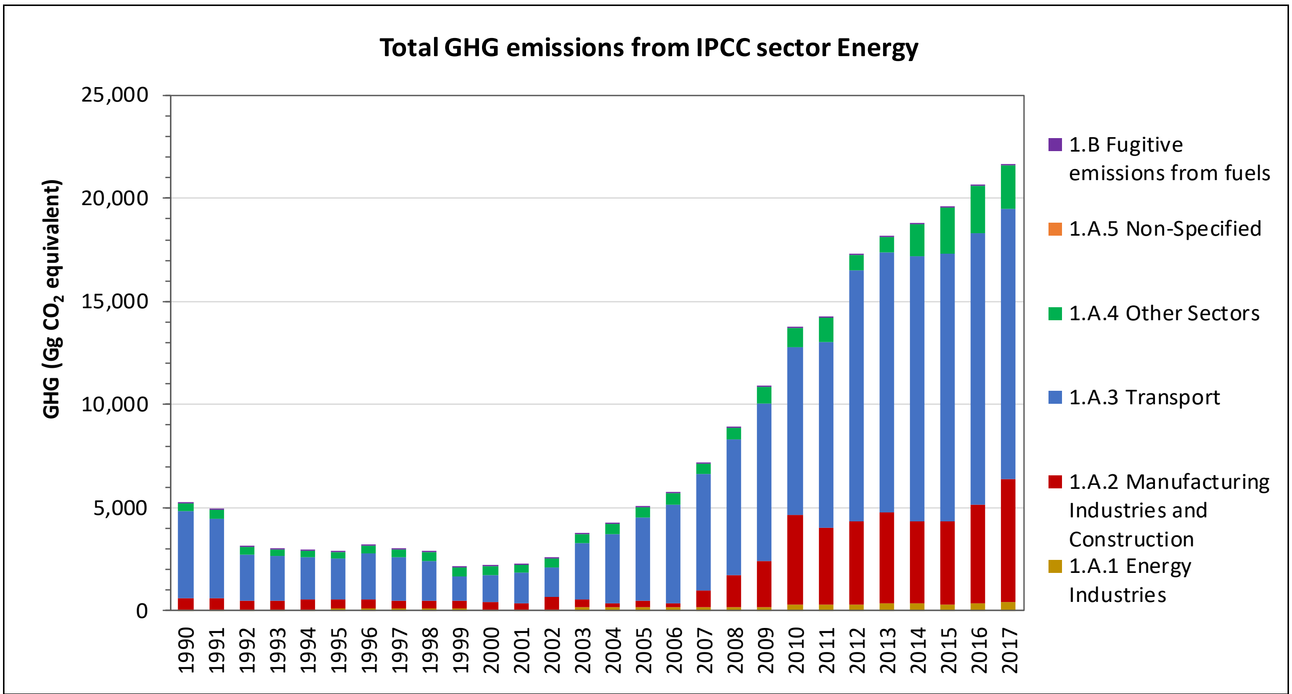


Figure 30 **Total national GHG emissions by category of sector Energy (1990-2017)**

The most important sources of GHGs in the Energy Sector is *Transport* and *Manufacturing Industries and Construction*. With regards to CO_2 emission, the source *Transport* was the primary source.

In the period 1990 to 2017 GHG emissions from the Energy Sector increased by 311% from 5,267.65 Gg CO_2 eq in 1990 to 21,649.43 Gg CO_2 eq in 2017, which is mainly caused by increasing emissions from fuel combustion in *Transport* (IPCC subcategory 1.A.3) and in *Manufacturing industries and construction* (IPCC subcategory 1.A.2).

In the period 2005 to 2017 GHG emissions from the Energy Sector increased by 327% from 5,066.98 Gg CO_2 eq in 2005 to 21,649.43 Gg CO_2 eq in 2017, which is mainly caused by increasing emissions from fuel combustion in *Transport* (IPCC subcategory 1.A.3) and in *Manufacturing industries and construction* (IPCC subcategory 1.A.2).

In the period 2016 to 2017 GHG emissions from the Energy Sector increased by 1.4% from 20,664.69 Gg CO_2 eq in 2016 to 21,649.43 Gg CO_2 eq in 2017, which is mainly caused by increasing emissions from fuel combustion in *Manufacturing industries and construction* (IPCC subcategory 1.A.2).

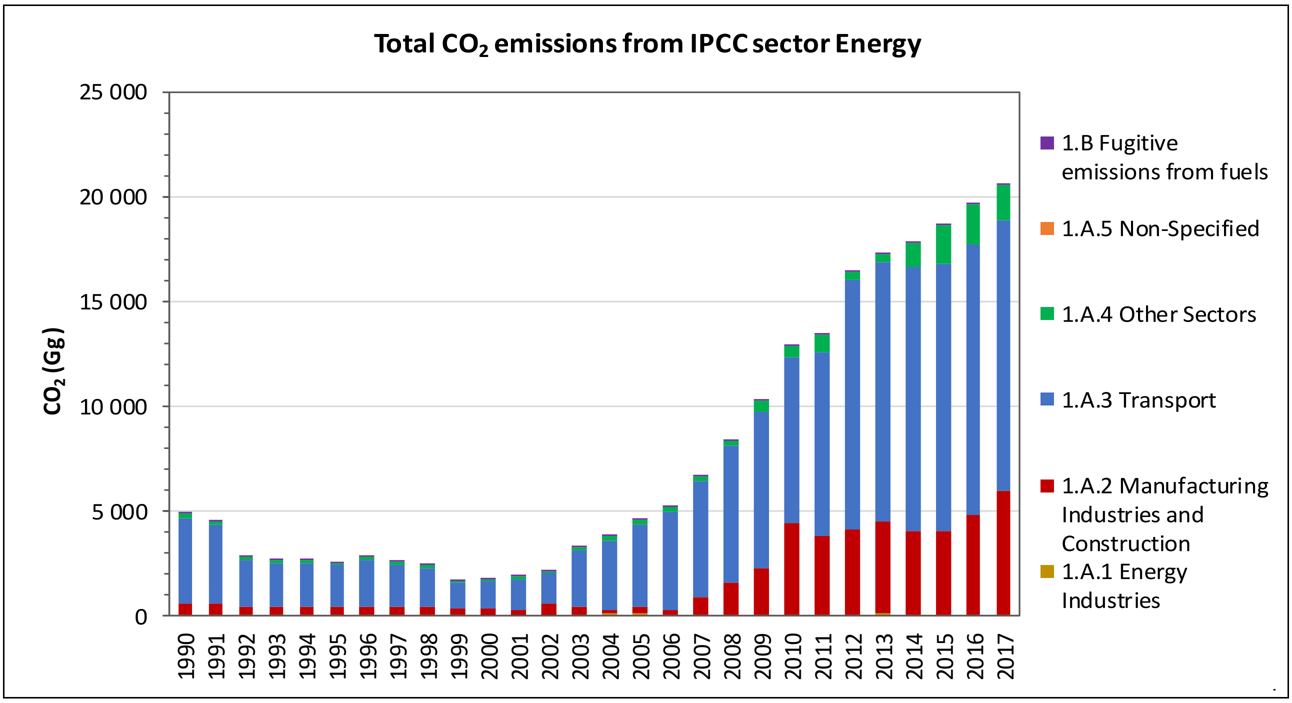


Figure 31 **Total national CO_2 emissions by category of sector Energy (1990-2017)**

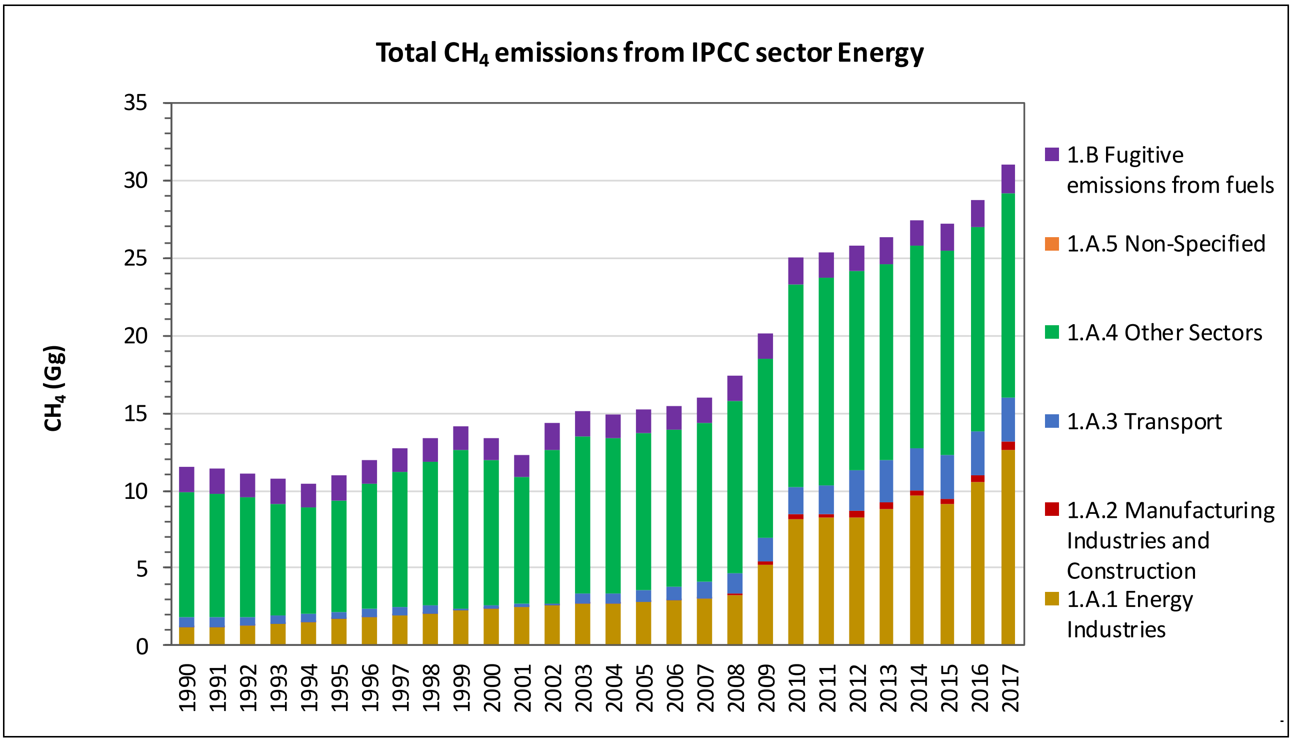


Figure 32 **Total national CH_4 emissions by category of sector Energy (1990-2017)**

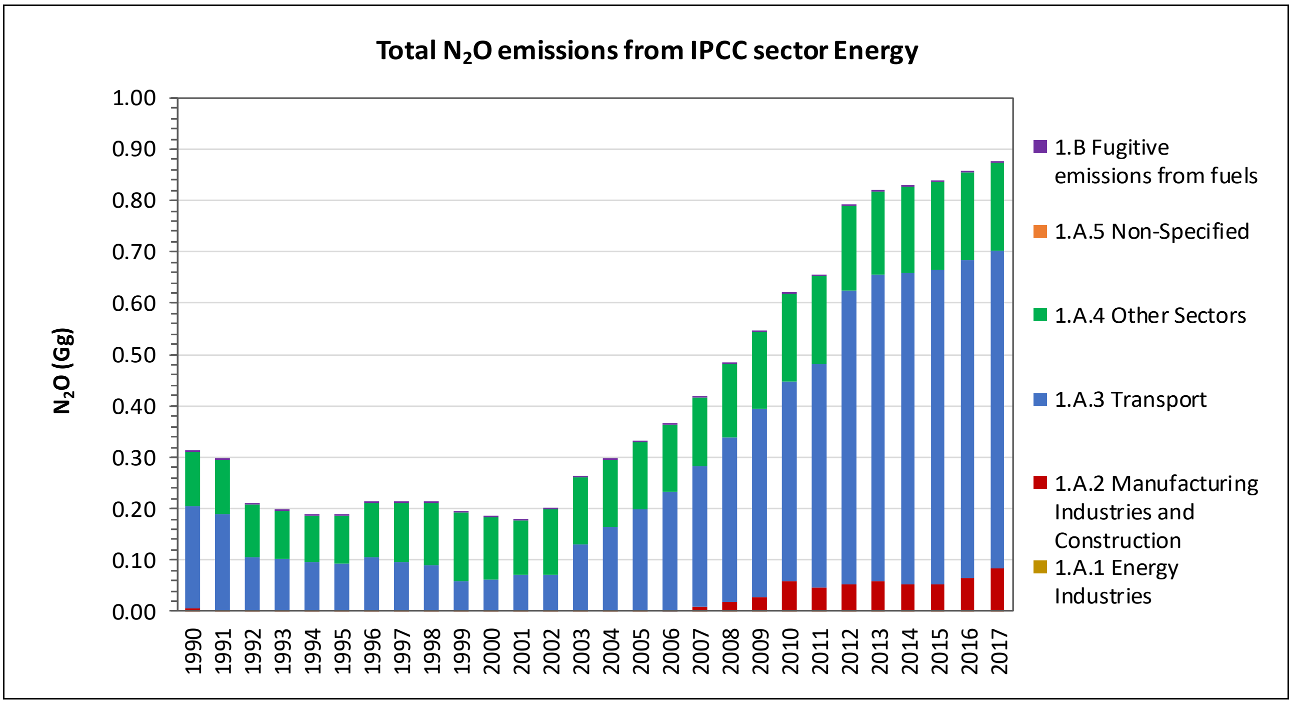


Figure 33 Total national N_2O emissions by category of sector Energy

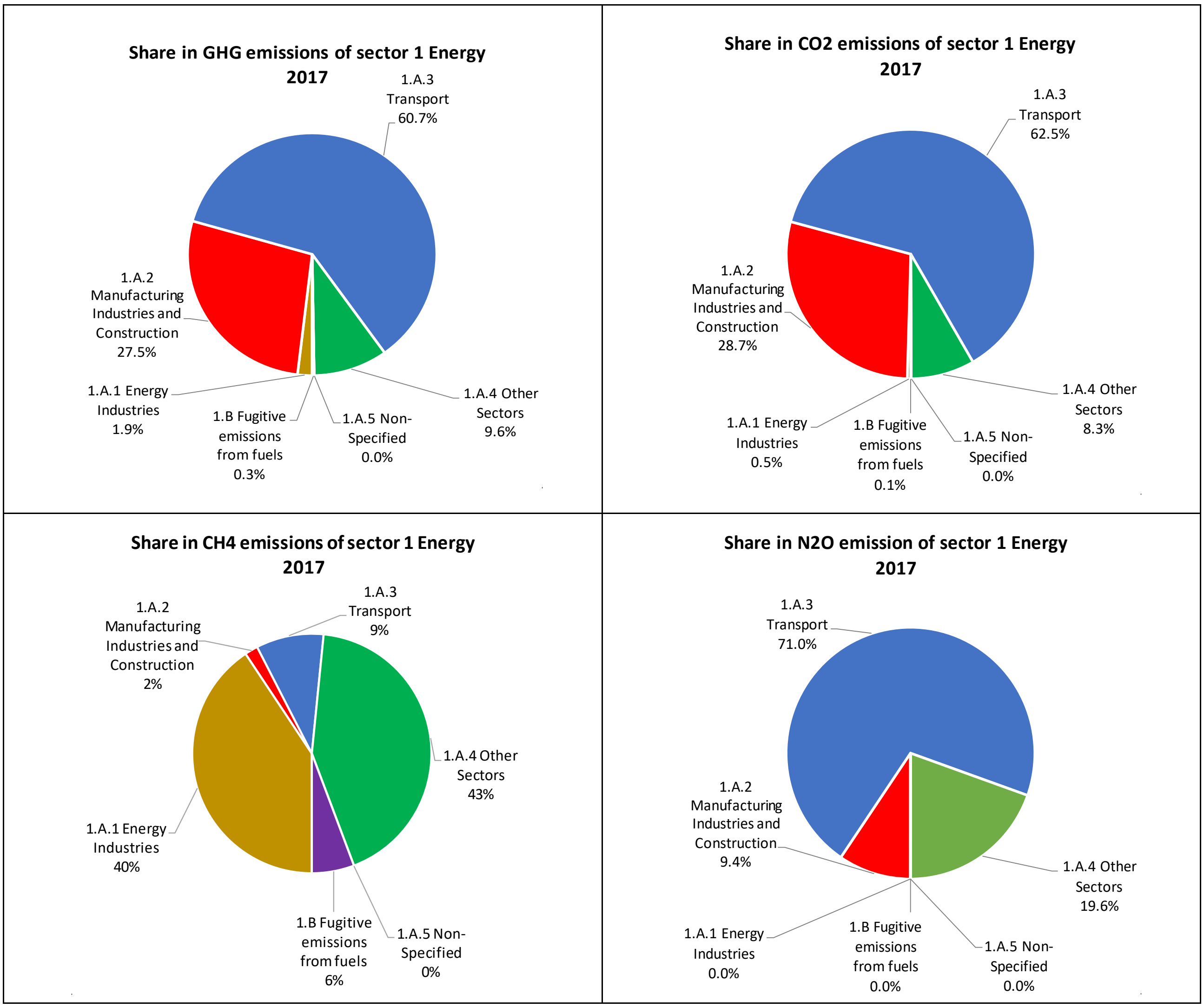


Figure 34 Share of GHG, CO_2, CH_4 and N_2O emissions in Sector 1 Energy in 2017

Table 46 Emissions of GHG, CO_2, CH_4 and N_2O from IPCC sector 1 Energy for 1990, 2000, 2005, 2010, 2012 and 2015 - 2017

Greenhouse gas source and sink categories		1990	2000	2005	2010	2012	2015	2016	2017	Trend 1990 - 2017	Trend 2005 - 2017	Trend 2016 - 2017
Greenhouse gas emissions (GHG)												
1	**Energy**	5,267.65	2,178.63	5,066.98	13,749.13	17,324.81	19,614.68	20,664.69	21 649.43	311.0%	327.3%	4.8%
1.A	Fuel Combustion Activities	5,211.22	2,132.61	5,014.71	13,696.92	17,270.70	19,561.77	20,609.17	21 593.37	314.4%	330.6%	4.8%
1.A.1	Energy Industries	74.65	67.30	200.44	296.63	301.92	292.41	336.20	408.05	446.6%	103.6%	21.4%
1.A.2	Manufacturing Industries & Construction	538.80	374.35	281.90	4,372.45	4,040.54	4,040.48	4,816.94	5 962.76	1,006.7%	2,015.2%	23.8%
1.A.3	Transport	4,190.11	1,289.07	4,027.38	8,094.18	12,156.56	13,015.30	13,136.61	13 136.61	213.5%	226.2%	0.0%
1.A.4	Other Sectors	407.66	401.89	504.99	933.67	771.67	2,213.58	2,319.42	2 085.95	411.7%	313.1%	-10.1%
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE			
1.B	Fugitive emissions from fuels	56.43	46.02	52.27	52.21	54.11	52.91	55.52	56.05	-0.7%	7.2%	1.0%
1.B.1	Solid Fuels	32.73	32.50	32.57	35.72	35.43	35.51	36.20	37.27	13.9%	14.4%	3.0%
1.B.2	Oil and Natural Gas	23.70	13.52	19.70	16.49	18.68	17.40	19.33	18.78	-20.7%	-4.7%	-2.8%
Total national GHG emissions (without LULUCF)		**18,076.57**	**15,627.54**	**22,453.86**	**36,102.42**	**39,924.62**	**41,995.19**	**42,880.77**	**43,471.39**	**140.5%**	**93.6%**	**1.4%**
CO_2 emissions												
1	**Energy**	4,886.21	1,788.28	4,587.71	12,939.46	16,443.91	18,685.63	19,692.65	20,615.03	321.9%	349.4%	4.7%
1.A	Fuel Combustion Activities	4,870.53	1,779.55	4,574.83	12,929.10	16,432.20	18,674.95	19,680.58	20,603.33	323.0%	350.4%	4.7%
1.A.1	Energy Industries	45.74	7.68	128.76	93.50	93.97	63.78	72.41	93.30	103.9%	-27.5%	28.9%
1.A.2	Manufacturing Industries & Construction	536.90	373.58	281.50	4,345.87	4,016.52	4,016.18	4,787.07	5,924.39	1,003.4%	2,004.6%	23.8%
1.A.3	Transport	4,114.52	1,266.88	3,951.73	7,935.87	11,919.48	12,761.96	12,881.00	12,881.00	213.1%	226.0%	0.0%
1.A.4	Other Sectors	173.37	131.40	212.84	553.87	402.23	1,833.02	1,940.11	1,704.65	883.2%	700.9%	-12.1%
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE			
1.B	Fugitive emissions from fuels	15.67	8.74	12.88	10.36	11.70	10.68	12.07	11.71	-25.3%	-9.1%	-3.0%
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA			
1.B.2	Oil and Natural Gas	15.67	8.74	12.88	10.36	11.70	10.68	12.07	11.71	-25.3%	-9.1%	-3.0%
Total national CO_2 emissions (without LULUCF)		**5,191.09**	**1,855.62**	**4,774.58**	**13,201.51**	**16,770.99**	**18,993.95**	**20,045.39**	**20,934.98**	**303.3%**	**338.5%**	**4.4%**

Greenhouse gas source and sink categories		1990	2000	2005	2010	2012	2015	2016	2017	Trend 1990 - 2017	Trend 2005 - 2017	Trend 2016 - 2017
						CH_4 emissions						
1	**Energy**	11.55	13.42	15.25	25.00	25.81	27.18	28.70	30.96	168.1%	103.0%	7.9%
1.A	Fuel Combustion Activities	9.92	11.93	13.68	23.32	24.12	25.49	26.96	29.18	194.2%	113.4%	8.3%
1.A.1	Energy Industries	1.15	2.38	2.85	8.12	8.31	9.14	10.55	12.59	992.5%	340.9%	19.3%
1.A.2	Manufacturing Industries & Construction	0.03	0.01	0.01	0.38	0.35	0.35	0.43	0.55	1,942.3%	8,695.5%	28.3%
1.A.3	Transport	0.64	0.16	0.69	1.67	2.65	2.81	2.83	2.83	342.8%	312.7%	0.0%
1.A.4	Other Sectors	8.10	9.38	10.13	13.15	12.81	13.19	13.15	13.21	63.1%	30.5%	0.5%
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE			
1.B	Fugitive emissions from fuels	1.63	1.49	1.58	1.67	1.70	1.69	1.74	1.77	8.8%	12.6%	2.1%
1.B.1	Solid Fuels	1.31	1.30	1.30	1.43	1.42	1.42	1.45	1.49			
1.B.2	Oil and Natural Gas	0.32	0.19	0.27	0.25	0.28	0.27	0.29	0.28	-11.8%	3.8%	-2.5%
Total national CH_4 emissions (without LULUCF)		**382.37**	**441.47**	**490.22**	**659.68**	**644.39**	**651.91**	**652.50**	**656.74**	**71.8%**	**34.0%**	**0.6%**
						N_2O emissions						
1	**Energy**	0.31	0.18	0.33	0.62	0.79	0.84	0.85	0.87	180.9%	165.8%	2.3%
1.A	Fuel Combustion Activities	0.31	0.18	0.33	0.62	0.79	0.84	0.85	0.87	180.9%	165.8%	2.3%
1.A.1	Energy Industries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-7.1%	-67.6%	30.0%
1.A.2	Manufacturing Industries & Construction	0.00	0.00	0.00	0.06	0.05	0.05	0.06	0.08	1,911.2%	10,070.2%	28.6%
1.A.3	Transport	0.20	0.06	0.20	0.39	0.57	0.61	0.62	0.62	210.1%	216.0%	0.0%
1.A.4	Other Sectors	0.11	0.12	0.13	0.17	0.17	0.17	0.17	0.17	60.3%	30.7%	0.6%
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE			
1.B	Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-24.4%	-8.3%	-3.0%
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA			
1.B.2	Oil and Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-24.4%	-8.3%	-3.0%
Total national N_2O emissions (without LULUCF)		**11.16**	**9.18**	**18.20**	**21.51**	**23.64**	**22.50**	**21.89**	**20.53**	**83.9%**	**12.8%**	**-6.2%**

2.2.1.1 Energy Industries (IPCC subcategory 1.A.1)

GHG emissions occur from fuel combustion for producing heat and electricity for the public, in refineries, and for manufacturing of solid fuels.

1.A.1.a Electricity production

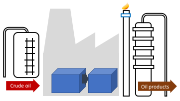
GHG emissions occur from fuel combustion for producing heat and electricity for the public (sold to industry, commercial, households, etc.). Nearly all of the thermal generation comes from reciprocating engines with the exception of the Kabul NE power plant, which consists of two diesel - fired gas turbines. No solid fuels are used for electricity production.

Trend 1A.1.a is a small source of GHG emissions as hydropower and imports of electricity are the main source for heat and electricity production in Afghanistan. Fluctuation of fuel consumption and emissions are due to

increased electricity consumption for heating coupled with non-availability of hydropower in winter and during droughts;

the War in Afghanistan.

1.A.1.b Petroleum Refining



GHG emissions occur from fuel combustion activities for heat and electricity production used in compressors, pumps and cracker furnaces within the refineries. Few small petroleum refineries are existing in Afghanistan. Natural gas liquids (NGL) was explored and refined for many years, a small amount of crude oil was explored and refined in the last years.

Trend Increased fuel consumption and emissions are due to

increasing demand of oil products;

rising capacities of the refineries;

constructing of new refineries.

1.A.1.c Manufacture of Solid Fuels

GHG emissions occur from fuel combustion activities in coke oven manufacturing facilities. Additionally, a significant amount of CH_4 emissions occur during the pyrolysis of the hard coal at temperatures of about 1,000°C. In Afghanistan, the production of coke oven coke is not integrated into an iron and steel industry plant. Coke oven coke is produced from national hard coal and is mainly exported.

Another significant amount of GHG emissions occur from charcoal production via slow pyrolysis: heating of wood or other organic materials in the absence of oxygen.

Trend Starting of coke oven coke production in 2008 with strongly rising production. Coke oven coke is completely exported.

Increasing production and consumption of charcoal due to the rising demand for fuel especially by households for heating and cooking.

2.2.1.2 Manufacturing Industries and Construction (IPCC subcategory 1.A.2)

GHG emissions occur from fuel combustion for producing heat and electricity in manufacturing industries and construction activities. The national energy statistics did not provide information regarding the use of fuels in the different IPCC subcategories of IPCC category 1.A.2. Therefore, all emissions except those for IPCC subcategory 1.A.2.c *Chemicals* where natural gas is combusted are reported under IPCC subcategory 1.A.2.m *Other*.

1.A.2.c Chemicals

GHG emissions occur from fuel combustion for producing heat and electricity in the chemical industry. The Power Plant at Kod-e-Barq was built at the same time as the Fertilizer Plant primarily to provide power to the large number of compressors and pumps that the Fertilizer Plant employs. Small amount of electricity and heat was also provided to the neighboring villages. It has a rated capacity of 48 MW, from four turbine generators of 12 MW each. The steam for the turbines is supplied by five water tube boilers run on natural gas. During the time not all turbines and boilers were working.

Trend Fluctuation of fuel consumption and emissions due to

- shortage of natural gas because of damaged and/or destroyed pipelines;
- start-ups and shut-downs as well as maintenance periods of the fertilizer plant.

1.A.2.m Other

GHG emissions occur from fuel combustion for producing heat and electricity through construction activities (1.A.2.k) as well as by the following manufacturing industries:

- *Iron and Steel* (1.A.2.a)
- *Non-Ferrous Metals* (1.A.2.b)
- *Pulp, Paper and Print* (1.A.2.d)
- *Food Processing, Beverages & Tobacco* (1.A.2.e)
- *Non-Metallic Minerals* (1.A.2.f)
- *Mining (excluding fuels) and Quarrying* (1.A.2.i)
- *Wood and wood products* (1.A.2.j)
- *Textile and Leather* (1.A.2.l)

In the energy-intensive cement and lime industry (1.A.2.f) mainly hard coal (coking coal, other bituminous coal) was combusted. The other industries are combusting also a significant amount of liquid fuels.

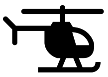
Trend Increasing and fluctuating fuel consumption and emissions are due to

- various industries of different configuration (boiler size, pumps, etc.);
- maintenance periods of big plants (e.g. cement and lime plant);
- availability of fuels and/or (imported) electricity;
- availability of raw material (e.g. iron scrap);
- growing diversification of the manufacturing industries;
- stabilization of industrial activities;
- the War in Afghanistan.

2.2.1.3 Transport (IPCC subcategory 1.A.3)

1.A.3.a

National and International Aviation



GHG emissions occur from *international* and *domestic civil aviation*, including take-offs and landings, and combusting Aviation and Jet Gasoline and Jet Kerosene.

The split between international and domestic aviation is based on departure and landing locations for each flight stage and not by the nationality of the airline. The energy statistics of UNSD provided fuel consumption for domestic and international aviation.

The GHG emissions of domestic civil aviation are included in 'Total national GHG emissions', whereas the GHG emissions of international civil aviation are reported under *International Bunkers* and therefore excluded from 'Total national GHG emissions'.

Trend Increasing and fluctuating fuel consumption and emissions are due to:

- an increase in the number of air passengers carried;
- a growing air freight volume (tonne-kilometres) as a result of growing imports of goods;
- the War in Afghanistan.

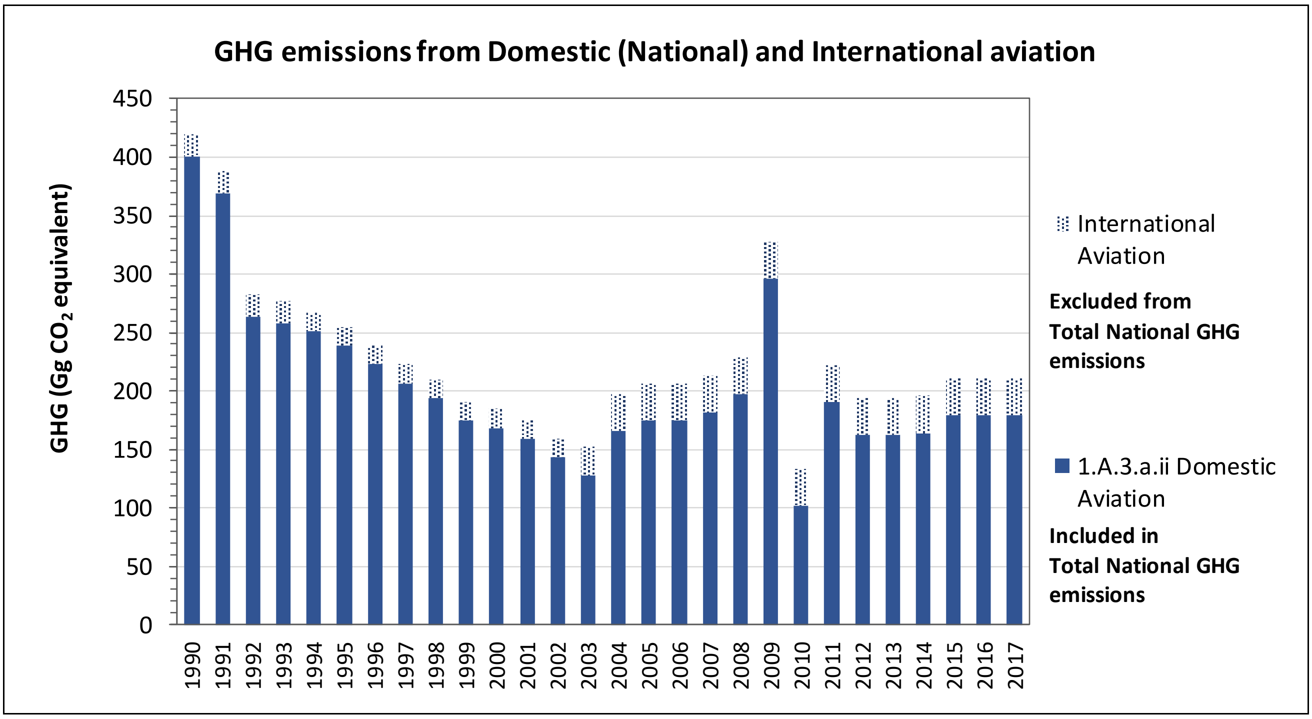


Figure 35 **GHG emission from Domestic (National) and International Aviation**

1.A.3.b Road Transport

All combustion and evaporative emissions arising from fuel use (diesel, gasoline, LPG) in road vehicles, including the use of agricultural vehicles on paved roads.

The GHG emissions were calculated by a combination of top-down and bottom-up:

Top-down: the amount of fuel sold provided in energy statistics and import statistics.

Bottom-up: number of vehicles (motorbikes, passenger cars, vans, buses and coaches, trucks) from national statistics, annual mileage, and average fuel consumption.

Trend Increasing and fluctuating fuel consumption and emissions are due to

- an increase of passenger kilometres (annual length of a journey by passengers who are travelling by motorbikes, passenger cars, vans, buses);
- an increase of freight kilometres (length of a journey of freight) with light- and heavy-duty trucks;
- growing number of private vehicles and rising mobility;
- the War in Afghanistan.

1.A.3.c Railway

GHG emissions occur from fuel combustion during railway transport for both freight and passenger traffic routes. In 2017, the total length of the railway was 123 km.

Landlocked Afghanistan has cargo transport to Hairatan river port at Amu Darya River (boarder – Hairatan river port: 18 km). All other rivers are not navigable.

1.A.3.d Navigation

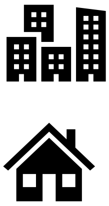
As the energy statistic does not split the fuel sold in the transport sector to different the transport modes (road, off-road, railway, navigation), all GHG emission are included in road transport. (1.A.3.b)

Kabul City ©Mohammad Monib Noori

2.2.1.4 Other Sectors and Not Specified (IPCC subcategory 1.A.4 and 1.A.5)

1.A.4

Other



GHG emissions occur from fuel combustion for heating and cooking purpose in

- *Commercial and institutional* buildings (1.A.4.a)
- *Residential buildings and households* (1.A.4.b)
- *Agriculture/Forestry/Fishing/Fish Farms* (1.A.4.c)

Stationary combustions are boilers (< 50 MW), pumps, stoves, fireplaces, cooking, etc. Mobile combustions are gardening equipment's and vehicles, fire trucks, sewage trucks, Snow mobiles, etc.

The national energy statistics do not provide a split of fuel used in this sector. The UN energy statistics and FAO statistics provided the amount of fuel used in this sector. All solid biomass fuels such as wood, charcoal, crop residues or animal dung are allocated to this sector.

Furthermore, based on expert judgment GHG emission from waste burned in households for cooking and heating was estimated.

The CO_2 from combustion of biomass for energy production (heat and electricity) is not included in the 'Total national GHG emissions' and reported as memo item.

Trend Increasing and fluctuating fuel consumption and emissions are due to

- wide variety of boilers, pumps, stoves, fireplaces;
- annual heating degree days: energy demand needed to heat building due to weather conditions;
- availability of electricity;
- increasing population.

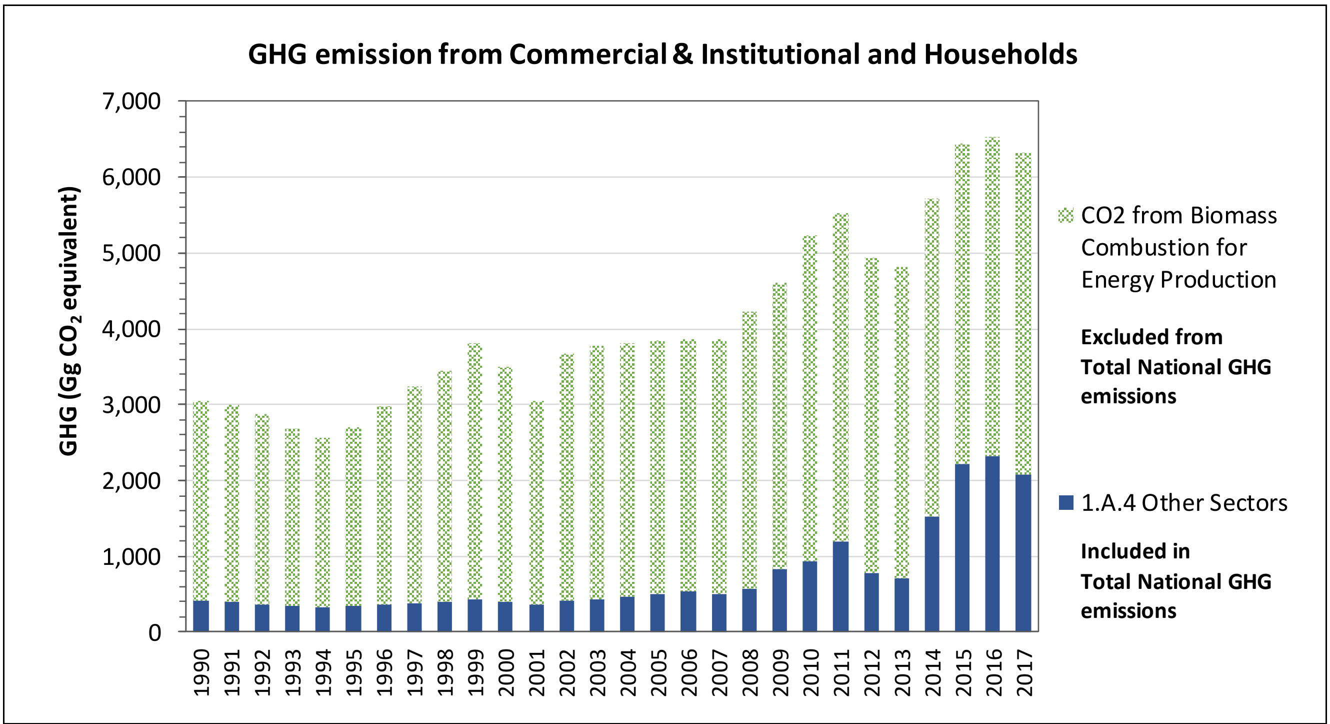


Figure 36 **GHG emissions from Commercial & Institutional and Households**

2.2.1.5 Fugitive emissions from fuels (IPCC subcategory 1.B)

1.B. Fugitive emissions from fuels

Fugitive emissions from fuels includes all intentional and unintentional emissions from the extraction, processing, storage and transport of fuel to the point of final use.

Trend Fluctuation of fuel consumption and emissions due to

- increased exploration and processing also for export (e.g. coke oven coke)
- old and/or damaged natural gas pipelines (180 km)
- increased imports of liquid fuels.

Pamir, Afghanistan © Mohammad Ayub Alavi

2.2.2 Industrial Processes and Product Use (IPPU) (IPCC sector 2)

Emissions from the IPCC sector **Industrial Processes and Product Use (IPPU)** are minor sources of GHGs in Afghanistan:

- in 1990 the GHG emission from this sector amounted to less than 1.4% of national total GHGs emissions. In the period 1990 and 2017 CO_2 emissions of sector IPPU changed only marginally. Emission decreases in category 2.B Chemical Industries were counterbalanced by emission increases in the sector 2.A Mineral Industry.
- in 2005 the GHG emission from this sector amounted to less than 0.7% of national total GHGs emissions. In the period 2005 and 2017 CO_2 emissions of sector IPPU increased by 50% mainly due to higher emissions in category 2.A Mineral Industries (higher lime production).
- Between 2016 and 2017, in the years 2012 and 2017 the GHG emission from this sector decreased by 12% and amounted in 2017 to 0.6% of national total GHGs emissions. The recent remarkable decrease is due to less emissions from category 2.A Mineral Industry.

Afghanistan is endowed with a wealth of natural resources like coal, petroleum oil and natural gas as well as iron ore, gold, copper, lead, etc., but currently only small amount of some of these resources were extracted. Refining and upgrading of the extracted resources like (primary) iron & steel industry do not take place so far.

Afghanistan has one fertilizer plant and four cement plants and lime production plant. For these industries, emissions were estimated.

The brick production takes place in small factories which produce the bricks still in traditional way. CO_2 emissions from brick production was not estimated as the amount of limestone used, and the annual limestone input was not available. Combustion related emissions are estimated as here the fuel combustion as included in energy statistics and allocated in IPCC subcategory 1.A.2.m *Other.*

GHG Emissions from consumption of halocarbons and SF_6 are not estimated due to following obstacles:

Import and export	• Import and export statistics provide only overall data of imported refrigerator and air conditions. No specifications, as well as type and amount of gases were available. • Lack of data and completeness is not ensured regarding F-gas content and F-gas composition
Stock of products containing F-gases	• Lack of data and/or completeness is not ensured • Assumption for identification of relevant F-gases and/or blends at this stage not reliable.

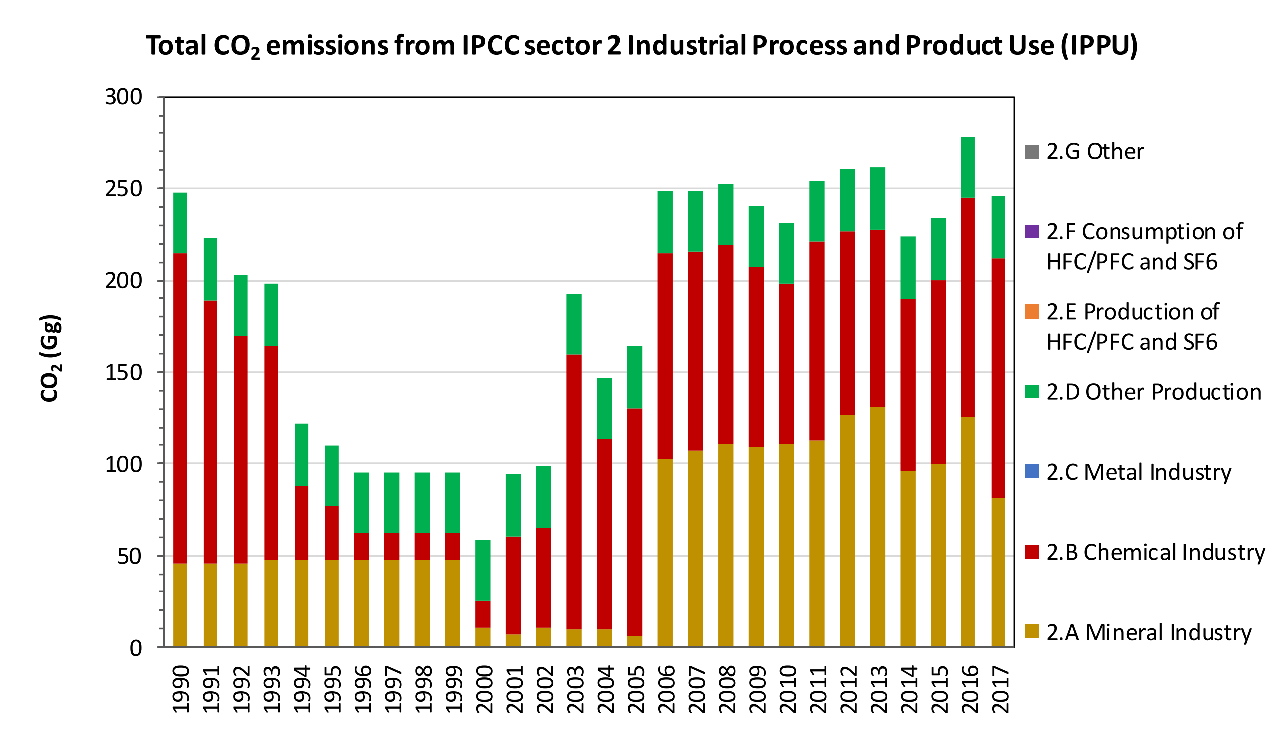


Figure 37 Total CO_2 emissions from IPCC sector 2 Industrial Processes and Product Use (IPPU)

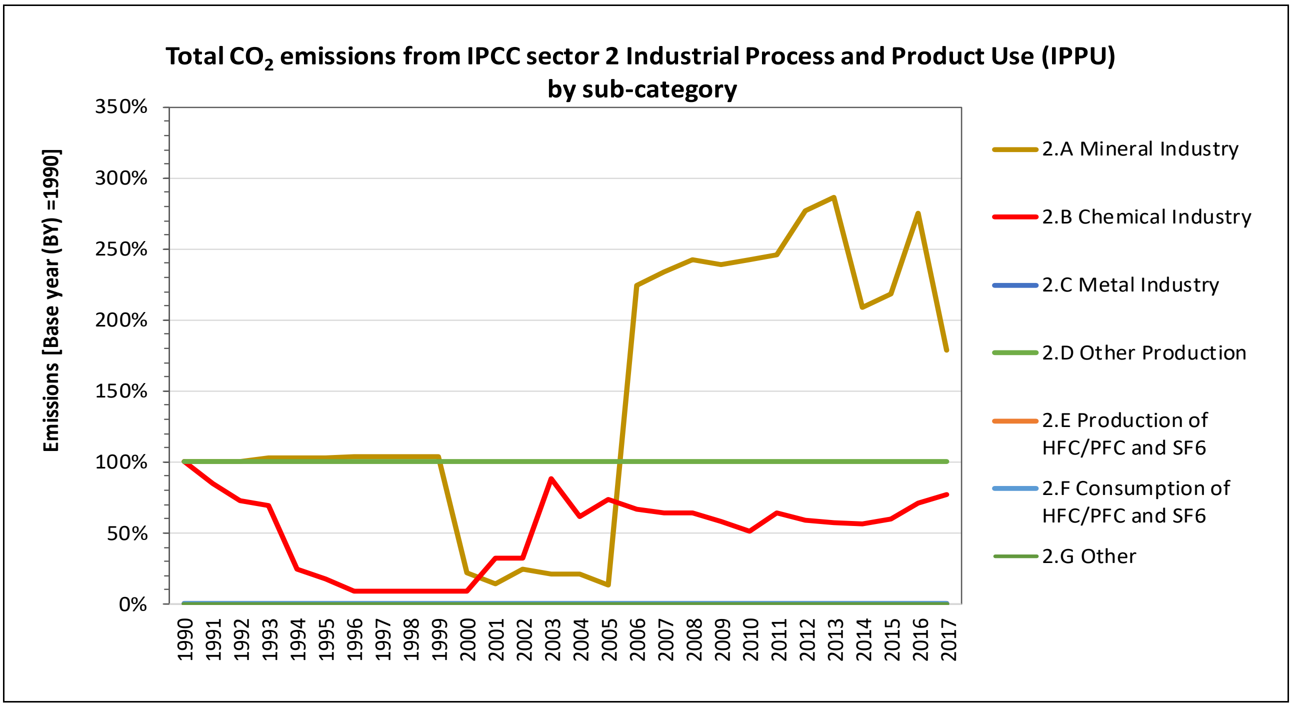


Figure 38 Trend in CO_2 emissions 1990–2017 in index form (base year = 100) of sector 2 Industrial Processes and Product Use (IPPU)

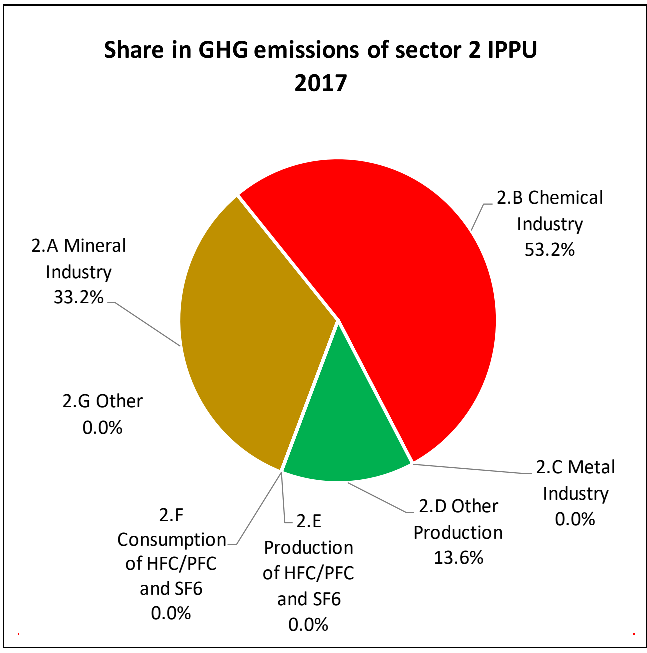


Figure 39 Share in CO_2 emissions of sector 2 Industrial Processes and Product Use (IPPU) in 1990

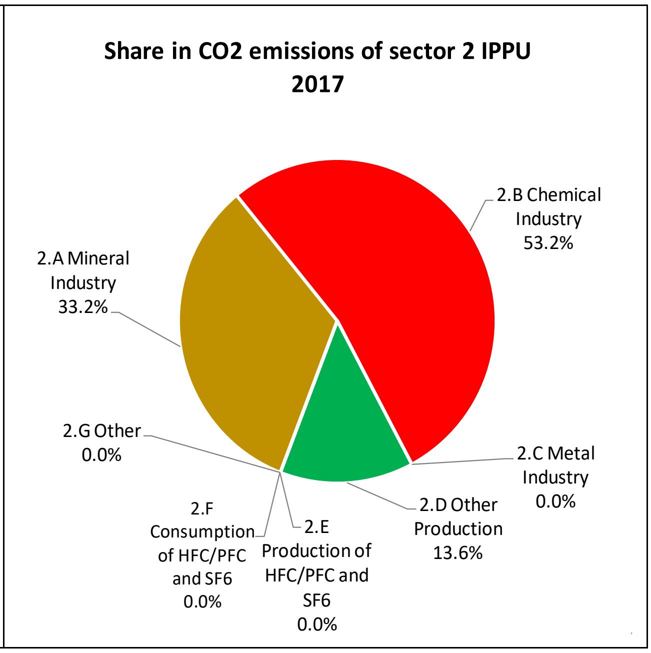


Figure 40 Share in CO_2 emissions of sector 2 Industrial Processes and Product Use (IPPU) in 2017

POPS Survey, Kabul ©UNEP

Table 47 Emissions of GHG of IPCC Sector 2 Industrial Processes and Product Use (IPPU) for 1990, 2000, 2005, 2010, 2012 and 2015 - 2017

Greenhouse gas source and sink categories		1990	2000	2005	2010	2012	2015	2016	2017	Trend		
										1990 - 2017	2005 - 2017	2016 - 2017
Greenhouse gas emissions (GHG)												
2	**IPPU**	248.13	58.48	163.84	231.32	260.30	233.87	278.59	245.78	-0.9%	50.0%	-11.8%
2.A	Mineral Industry	45.77	10.22	6.21	110.93	126.82	99.92	125.82	81.68	78.5%	1215.1%	-35.1%
2.B	Chemical Industry	168.93	14.83	124.19	86.96	100.04	100.51	119.33	130.67	-22.6%	5.2%	9.5%
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.D	Non-Energy Products f. Fuels & Solvent Use	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	0.0%	0.0%	0.0%
2.E	Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.F	Production of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2.G	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
Total national GHG emissions (without LULUCF)		**18 076.57**	**15 627.54**	**22 453.86**	**36 102.42**	**39 924.62**	**41 995.19**	**42 880.77**	**43 471.39**	**140.5%**	**93.6%**	**1.4%**
CO_2 emissions												
2	**IPPU**	248.13	58.48	163.84	231.32	260.30	233.87	278.59	245.78	-0.9%	50.0%	-11.8%
2.A	Mineral Industry	45.77	10.22	6.21	110.93	126.82	99.92	125.82	81.68	78.5%	1215.1%	-35.1%
2.B	Chemical Industry	168.93	14.83	124.19	86.96	100.04	100.51	119.33	130.67	-22.6%	5.2%	9.5%
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.D	Non-Energy Products f. Fuels & Solvent Use	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	0.0%	0.0%	0.0%
2.E	Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.F	Production of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2.G	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
Total national GHG emissions (without LULUCF)		**5 191.09**	**1 855.62**	**4 774.58**	**13 201.51**	**16 770.99**	**18 993.95**	**20 045.39**	**20 934.98**	**303.3%**	**338.5%**	**4.4%**

Greenhouse gas source and sink categories		1990	2000	2005	2010	2012	2015	2016	2017	Trend		
										1990 - 2017	2005 - 2017	2016 - 2017
CH_4 emissions												
2	**IPPU**	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.D	Non-Energy Products f. Fuels & Solvent Use	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.E	Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.F	Production of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2.G	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
Total national GHG emissions (without LULUCF)		**382.37**	**441.47**	**490.22**	**659.68**	**644.39**	**651.91**	**652.50**	**656.74**	**71.8%**	**34.0%**	**0.6%**
N_2O emissions												
2	**IPPU**	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.D	Non-Energy Products f. Fuels & Solvent Use	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.E	Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
2.F	Production of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2.G	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
Total national GHG emissions (without LULUCF)		**11.16**	**9.18**	**18.20**	**21.51**	**23.64**	**22.50**	**21.89**	**20.53**	**83.9%**	**12.8%**	**-6.2%**

In the following an overview of the relevant categories, the cause of emissions and the key drivers for the trend is provided. For information on the methodologies applied to calculate emissions from each category, see chapter 5.

2.2.2.1 Cement Production (IPCC Subcategory 2.A.1)

2.A.1

Cement Production

CO_2 emission originate from the production of clinker, where the raw material limestone, which is mainly calcium carbonate ($CaCO_3$), is heated, or calcined, to produce lime (CaO) and CO_2 as a by-product. The CaO then reacts with silica (SiO_2), alumina (Al_2O_3), and iron oxide (Fe_2O_3) in the raw materials to make the clinker minerals (chiefly calcium silicates). The clinker is finally cooled down, grained and mixed.

Trend Increasing CO_2 emissions were due to increased cement production. At the same time fluctuation which were due to the bad conditions of the cement plants, could be observed.

2.2.2.2 Lime Production (IPCC Subcategory 2.A.2)

2.A.2

Lime Production

CO_2 emission originate from the production of quicklime, using limestone and dolomite as raw material.

Trend Increasing CO_2 emissions were due to increased lime production which started in 2008.

2.2.2.3 Ammonia and Urea Production (IPCC Subcategory 2.B.1)

2.B.1

Ammonia Production - Urea Production

CO_2 emissions originate from the production of urea as downstream process in the ammonia plant. The process of ammonia production is based on the ammonia synthesis loop (also referred to as the Haber-Bosch process) reaction of nitrogen (derived from process air) with hydrogen to form anhydrous liquid ammonia. The hydrogen is derived from feedstock as natural gas (conventional steam reforming route). CO_2 is recovered for the production of Urea.

Trend Increasing CO_2 emissions were due to rising amount of urea. Observed fluctuations were due to start-up and maintenance period and lack of natural gas.

2.2.2.4 Non-Energy Products (IPCC Subcategory 2.D.1)

2.D.1

Non-Energy Products from Fuels and Solvent Use

CO_2 emission originate from the first use (combustion) of fossil fuels as a product (Lubricant Use, Paraffin Wax Use) used in small engines.

Trend Constant emissions over the years were observed.

2.2.3 Agriculture (IPCC Sector 3)

In the year 2017, the sector **agriculture** excluding LULUCF Sector accounted for 20,073.90 Gg CO_2 eq which is equal to 46.2% of the Afghanistan's total greenhouse gas emissions in CO_2 eq. The trend of GHG emissions from 1990 to 2017 shows an increase of 73% for this sector due to an increase in livestock numbers and higher amounts of N-fertilizers applied on agricultural soils.

In the **IPCC sector Agriculture,** GHG emissions originate from:

- Enteric Fermentation (Livestock husbandry) (IPCC category 3.A) with 23.6% in 2017 of total National GHG emissions,
- Manure management (IPCC category 3.B) with 5.0% in 2017 of total National GHG emissions,
- Rice Cultivation (IPCC category 3.C) with 4.7% in 2017 of total National GHG emissions,
- Agricultural soils (IPCC category 3.D) with 12.6% in 2017 of total National GHG emissions,
- Agricultural Residue Burning (IPCC category 3.F) with less than 0.1% in 2017 of total National GHG emissions.
- CO_2 emissions from urea application (IPCC category 3.G) with 0.2% in 2017 of total National GHG emissions.

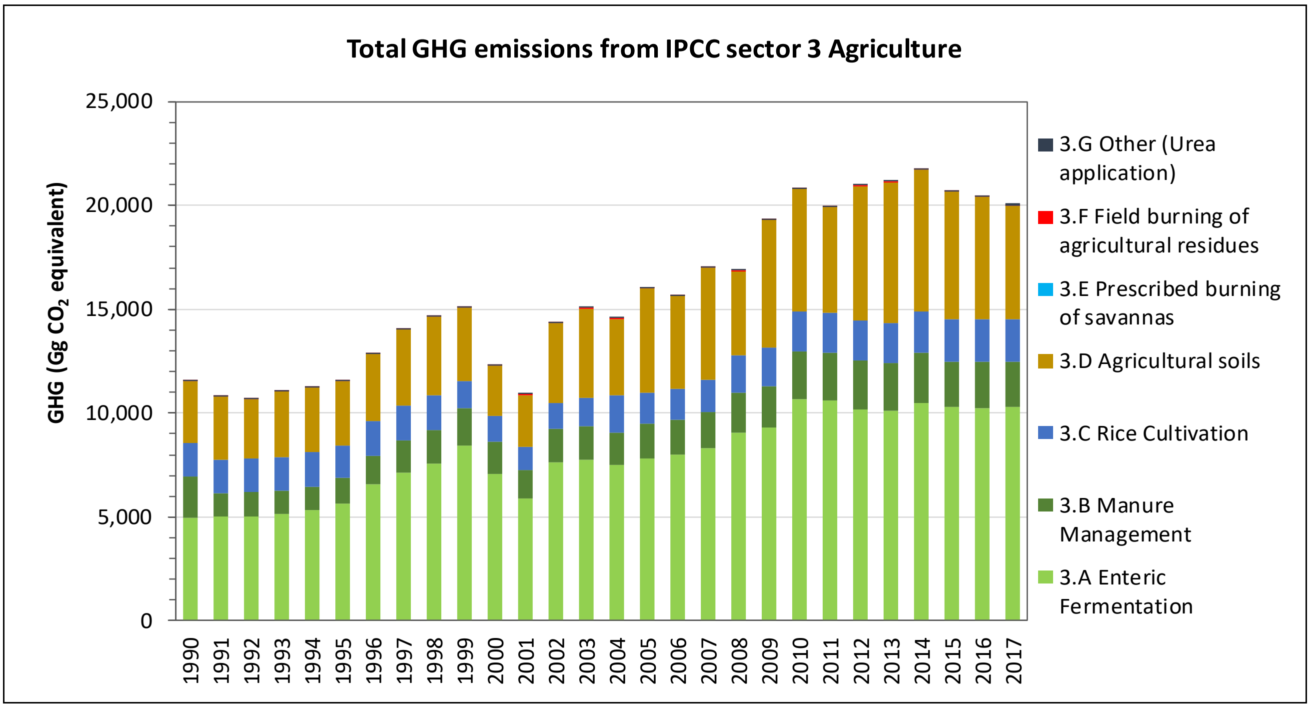


Figure 41 Total GHG emissions from IPCC sector 3 Agriculture

In 2017, **agriculture** sector with 87.6% of the total National CH_4 emissions and 92.0% of the total National N_2O emissions is an important source. The most important sources of GHGs in sector Agriculture were *Enteric fermentation* for CH_4 emissions and *Agricultural Soils* for N_2O emissions.

Between 1990 and 2010, CH_4 emissions (without LULUCF) from the agriculture sector increased by 75% and stayed afterwards relatively constant (-3% change between 2010 and 2017). In 2017 CH_4 emissions from the agriculture sector amounted to 575.05 Gg CH_4.

N_2O emissions mainly from category 3.D Agricultural Soils increased between 1990 and 2014 by 122%, but afterwards decreased to 18.89 Gg N_2O emissions in 2017 (-19% change between 2014 and 2017).

CO_2 emissions from sector Agriculture contribute with a share of 0.3% of national total CO_2 emissions, whereby the CO_2 emissions originate mainly from urea application (category 3.G).

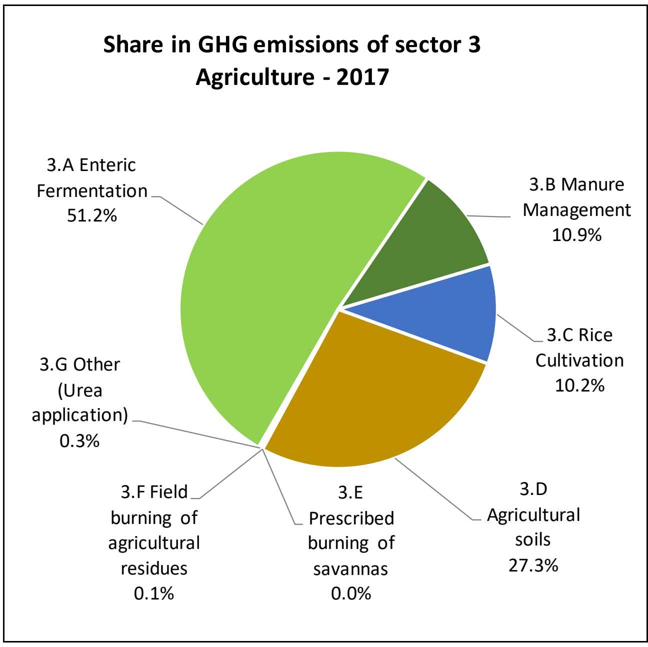


Figure 42 Share in GHG emissions of IPCC sector 3 Agriculture in 2017

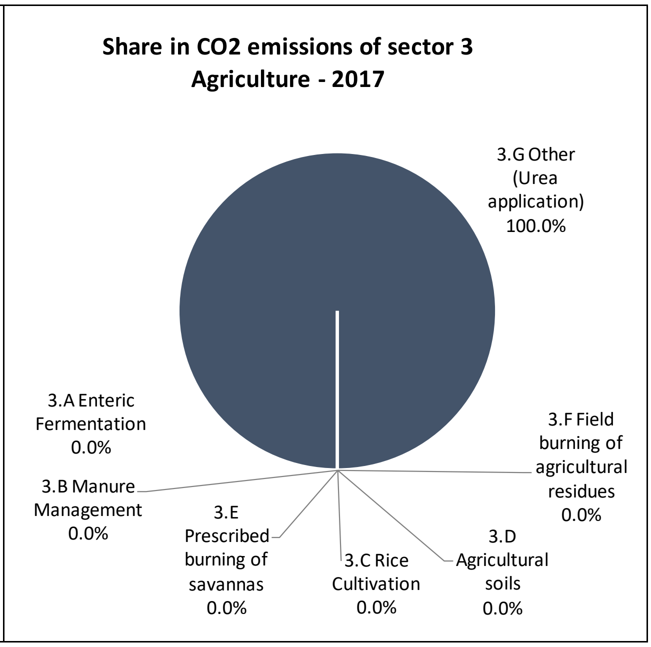


Figure 43 Share in CO_2 emissions of IPCC sector 3 Agriculture in 2017

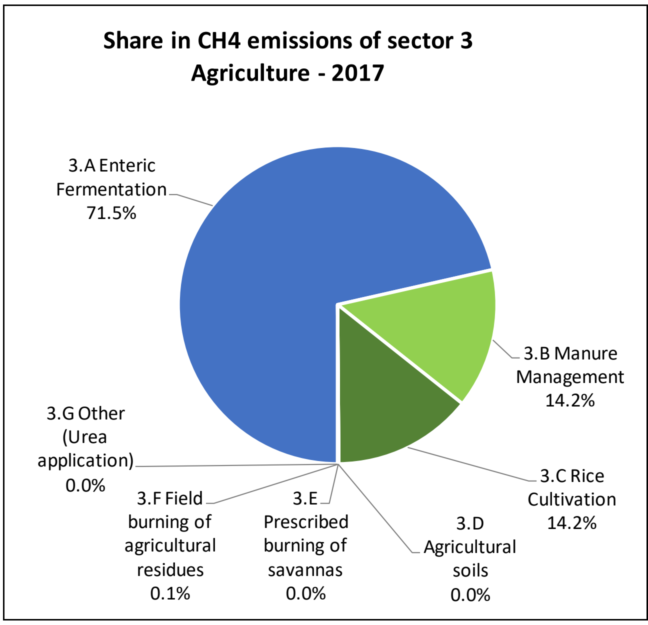


Figure 44 Share in CH_4 emissions of IPCC sector 3 Agriculture in 2017

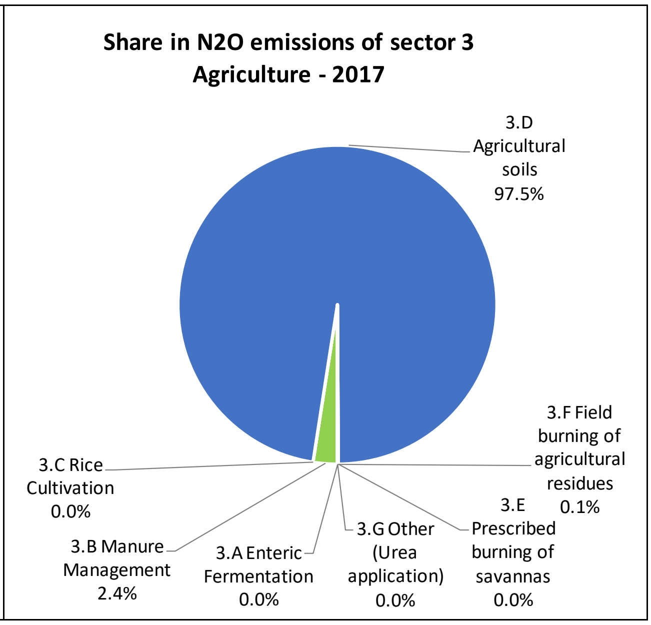


Figure 45 Share in N_2O emissions of IPCC sector 3 Agriculture in 2017

Table 48 Emissions of GHG of IPCC Sector 3 Agriculture for the Period of 1990, 2000, 2005, 2010, 2012 and 2015-2017

Greenhouse gas source and sink categories		1990	2000	2005	2010	2012	2015	2016	2017	Trend		
										1990 - 2017	2005 - 2017	2016 - 2017
Greenhouse gas emissions (GHG)												
3	**Agriculture**	11,623.10	12,302.26	16,036.89	20,831.46	21,006.13	20,729.34	20,490.89	20,073.90	**72.7%**	**25.2%**	**-2.0%**
3.A	Enteric Fermentation	4,976.19	7,097.63	7,814.80	10,650.74	10,194.85	10,309.18	10,265.21	10,273.23	**106.4%**	**31.5%**	**0.1%**
3.B	Manure Management	1,940.87	1,547.33	1,656.99	2,317.20	2,360.80	2,188.64	2,182.39	2,183.59	**12.5%**	**31.8%**	**0.1%**
3.C	Rice Cultivation	1,623.18	1,205.79	1,484.05	1,929.26	1,901.44	2,040.57	2,040.57	2,040.57	**25.7%**	**37.5%**	**0.0%**
3.D	Agricultural Soils	3,020.26	2,439.16	5,044.38	5,887.89	6,466.34	6,099.17	5,911.65	5,487.00	**81.7%**	**8.8%**	**-7.2%**
3.E	Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA			
3.F	Field Burning of Agricultural Residues	8.87	7.67	18.27	22.06	22.48	23.87	23.16	21.60	**143.6%**	**18.2%**	**-6.7%**
3.G	Other (Urea Application)	53.73	4.67	18.40	24.32	60.22	67.92	67.92	67.92	**26.4%**	**269.0%**	**0.0%**
Total national GHG emissions (without LULUCF)		**18,076.57**	**15,627.54**	**22,453.86**	**36,102.42**	**39,924.62**	**41,995.19**	**42,880.77**	**43,471.39**	**140.5%**	**93.6%**	**1.4%**
CO_2 emissions (Gg)												
3	**Agriculture**	53.73	4.67	18.40	24.32	60.22	67.92	67.92	67.92	**26.4%**	**269.0%**	**0.0%**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA			
3.B	Manure Management	NA	NA	NA	NA	NA	NA	NA	NA			
3.C	Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA			
3.D	Agricultural Soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
3.E	Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA			
3.F	Field Burning of Agricultural Residues	NA	NA	NA	NA	NA	NA	NA	NA			
3.G	Other (Urea Application)	53.73	4.67	18.40	24.32	60.22	67.92	67.92	67.92	**26.4%**	**269.0%**	**0.0%**
Total national GHG emissions (without LULUCF)		**5,191.09**	**1,855.62**	**4,774.58**	**13,201.51**	**16,770.99**	**18,993.95**	**20,045.39**	**20,934.98**	**303.3%**	**338.5%**	**4.4%**

Greenhouse gas source and sink categories		1990	2000	2005	2010	2012	2015	2016	2017	Trend		
										1990 - 2017	2005 - 2017	2016 - 2017
CH_4 emissions (Gg)												
3	**Agriculture**	338.05	389.97	434.33	590.96	573.48	576.75	574.74	575.05	**70.1%**	**32.4%**	**0.1%**
3.A	Enteric Fermentation	199.05	283.91	312.59	426.03	407.79	412.37	410.61	410.93	**106.4%**	**31.5%**	**0.1%**
3.B	Manure Management	73.79	57.59	61.78	87.06	88.90	82.01	81.79	81.83	**10.9%**	**32.5%**	**0.1%**
3.C	Rice Cultivation	64.93	48.23	59.36	77.17	76.06	81.62	81.62	81.62	**25.7%**	**37.5%**	**0.0%**
3.D	Agricultural Soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
3.E	Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO			
3.F	Field Burning of Agricultural Residues	0.28	0.24	0.60	0.71	0.73	0.75	0.73	0.67	**136.4%**	**12.4%**	**-7.3%**
3.G	Other (Urea Application)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Total national GHG emissions (without LULUCF)		**382.37**	**441.47**	**490.22**	**659.68**	**644.39**	**651.91**	**652.50**	**656.74**	**71.8%**	**34.0%**	**0.6%**
N_2O emissions (Gg)												
3	**Agriculture**	10.46	8.55	17.32	20.25	22.18	20.95	20.32	18.89	**80.5%**	**9.1%**	**-7.0%**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA			
3.B	Manure Management	0.32	0.36	0.38	0.47	0.46	0.46	0.46	0.46	**43.5%**	**22.5%**	**0.1%**
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO			
3.D	Agricultural Soils	10.14	8.19	16.93	19.76	21.70	20.47	19.84	18.41	**81.7%**	**8.8%**	**-7.2%**
3.E	Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO			
3.F	Field Burning of Agricultural Residues	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	**172.9%**	**44.7%**	**-4.6%**
3.G	Other (Urea Application)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Total national GHG emissions (without LULUCF)		**11.16**	**9.18**	**18.20**	**21.51**	**23.64**	**22.50**	**21.89**	**20.53**	**83.9%**	**12.8%**	**-6.2%**

In the following an overview of the relevant categories, the cause of emissions and the key drivers for the trend is provided. For information on the methodologies applied to calculate emissions from each category, see chapter 5.

2.2.3.1 Enteric Fermentation (IPCC Subcategory 3.A)

3.A

Enteric Fermentation

Methane is produced in herbivorous animals (plant eater) as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream. The amount of CH_4 that is released depends on the type of digestive tract, age, and weight of the animal, and the quality and quantity of the feed consumed. Ruminant livestock (e.g. cattle, sheep) are major sources of methane with moderate amounts produced from non-ruminant livestock (e.g. horses, mules and asses). CH_4 emission from the following animals were estimated:

- cattle (dairy cows, other cattle);
- sheep (dairy and non-dairy);
- goats (dairy and non-dairy);
- camels;
- horses;
- mules and asses;
- poultry.

Trend Fluctuation of CH_4 emissions were due to:

- decreased number of dairy cattle but increased number of non-dairy cattle,
- decreased number of sheep and goats

2.2.3.2 Manure Management (IPCC Subcategory 3B)

3.B

Manure Management

CH_4 is produced during the storage and treatment of manure, and from manure deposited on pasture. The decomposition of manure under anaerobic conditions (i.e., in the absence of oxygen), during storage and treatment, produces CH_4. The main factors affecting CH_4 emissions are the amount of manure produced and the portion of the manure that decomposes anaerobically.

Direct N_2O emissions occur via combined nitrification and denitrification 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, and on the duration of the storage and type of treatment.

- Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NO_x. The fraction of excreted organic nitrogen that is mineralized to ammonia nitrogen during manure collection and storage depends primarily on time, and to a lesser degree temperature.

CH_4 and N_2O emission were estimated from the livestock mentioned above and poultry.

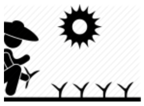
Trend Fluctuation of CH_4 emissions were due to:

- decreased number of dairy cattle but increased number of non-dairy cattle,
- decreased number of sheep and goats,
- increased number of poultries.

2.2.3.3 Rice Cultivation (IPCC Subcategory 3.C)

3.C

Rice Cultivation



Methane is produced by anaerobic decomposition of organic material in flooded rice fields. The CH_4 emits to the atmosphere primarily by transport through the rice plants.

Trend Increasing CH_4 emissions were due to increased area under rice during the last decade.

2.2.3.4 Agricultural Soils (IPCC Subcategory 3.D)

3.D

Agricultural soils

Direct N_2O emissions: In most soils, an increase in available nitrogen (N) enhances nitrification and denitrification rates which then increase the production of N_2O. Increases in available Nitrogen (N) can occur through human-induced N additions:

- synthetic N fertilisers;
- organic N applied as fertiliser (e.g. animal manure, compost, sewage sludge, etc.);
- urine and dung N deposited on pasture, range and paddock by grazing animals;
- N in crop residues (above-ground and below-ground), including from N-fixing crops and from forages during pasture renewal;
- N mineralisation associated with loss of soil organic matter resulting from change of land use or management of mineral soils; and
- drainage/management of organic soils.

Indirect N_2O emissions: in addition to the direct emissions of N_2O from managed soils that occur through a direct pathway (i.e. directly from the soils to which N is applied), emissions of N_2O also take place through two indirect pathways:

- volatilisation of N as NH_3 and oxides of N (NOx) and the deposition of these gases and their products NH_4^+ and NO_3^- onto soils and the surface of lakes and other waters;
- leaching and runoff from land of N from synthetic and organic fertiliser additions, crop residues, mineralisation of N associated with loss of soil C in mineral and drained/managed organic soils through land-use change or management practices, and urine and dung deposition from grazing animals.

Trend Decreasing and fluctuation of emissions were due to:

- increased consumption of synthetic fertilizer – urea,
- fluctuating amount of manure applied to soils,
- decreased amount of crop residues because of decreased crop production: e.g. wheat and barley, Maize, rice;
- increasing amount of crop residues because of increased crop production: peas, potatoes, sunflower.

2.2.3.5 Field Burning of Agricultural Residue (IPCC Subcategory 3.F)

3.F

Field burning of agricultural residues

GHG emissions occur from field burning of agricultural residues. This practice is not that much common in Afghanistan, as the residues are more used as fuel for cooking and heating.

Trend Decreasing and fluctuation of emissions were due to

- decreased amount of crop residues because of decreased crop production: e.g. wheat and barley, Maize, rice;
- increasing amount of crop residues because of increased crop production: peas, potatoes, sunflower.

2.2.3.6 Others (IPCC Subcategory 3.G)

3.G

Other (Urea application)

Adding urea to soils during fertilisation leads to a loss of CO_2 that was fixed in the industrial production process. 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.

Trend CO_2 emissions were fluctuating due to needs of the soil and availability of urea.

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2.2.4 Waste (IPCC Sector 5)

In 2017, greenhouse gas emissions from IPCC sector **Waste** amounted to 1,502.27 Gg CO_2 equivalents, which correspond to 3.5% of the total national emissions. From 1990 to 2017, emissions from this sector increased by 60%, mainly due to an increase in solid waste disposal and increased population. Between 2016 and 2017 emissions from sector Waste increased by 4%.

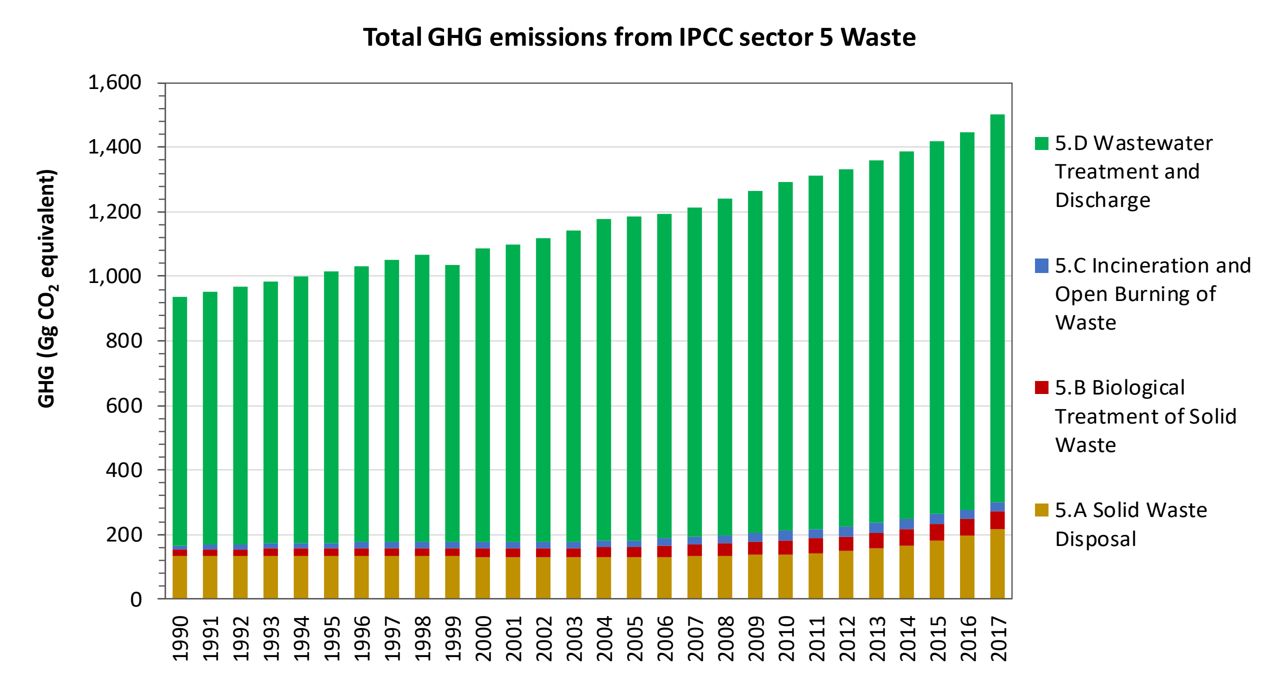


Figure 46 Total GHG emissions from IPCC sector 5 Waste

The GHG emissions of sector Waste originated in 1990 from

- Solid Waste Disposal (IPCC category 5.A) with about 0.7% of total national GHG emissions,
- Biological Treatment of Solid Waste (Composting) (IPCC category 5.B) with about 0.1% of total national GHG emissions.
- Incineration and Open Burning of Waste (IPCC category 5.C) with about 0.1% of total national GHG emissions,
- Wastewater Treatment and Discharge (IPCC category 5.D) with about 4.3% of total national GHG emissions.

In 1990, the most important greenhouse gas from Waste sector is CH_4 with a share of 8.6% in total GHG emissions from this sector, followed by N_2O with 3.5% and CO_2 with 0.1%.

In 2005 the GHG emissions of sector Waste originated from

- Solid Waste Disposal (IPCC category 5.A) with about 0.6% of total national GHG emissions,
- Biological Treatment of Solid Waste (Composting) (IPCC category 5.B) with about 0.1% of total national GHG emissions.
- Incineration and Open Burning of Waste (IPCC category 5.C) with about 0.1% of total national GHG emissions,
- Wastewater Treatment and Discharge (IPCC category 5.D) with about 4.5% of total national GHG emissions.

In 2005 the most important greenhouse gas from Waste sector is CH_4 with a share of 8.3% in total GHG emissions from this sector, followed by N_2O with 3.1% and CO_2 with 0.1%.

In 2017 the GHG emissions of sector Waste originated from

- Solid Waste Disposal (IPCC category 5.A) with about 0.5% of total national GHG emissions,
- Biological Treatment of Solid Waste (Composting) (IPCC category 5.B) with about 0.1% of total national GHG emissions.
- Incineration and Open Burning of Waste (IPCC category 5.C) with about 0.1% of total national GHG emissions,
- Wastewater Treatment and Discharge (IPCC category 5.D) with about 2.8% of total national GHG emissions.

The most important greenhouse gas from Waste sector in 2017 is CH_4 with a share of 7.7% in total GHG emissions from this sector, followed by N_2O with 3.7% and CO_2 with 0.03%.

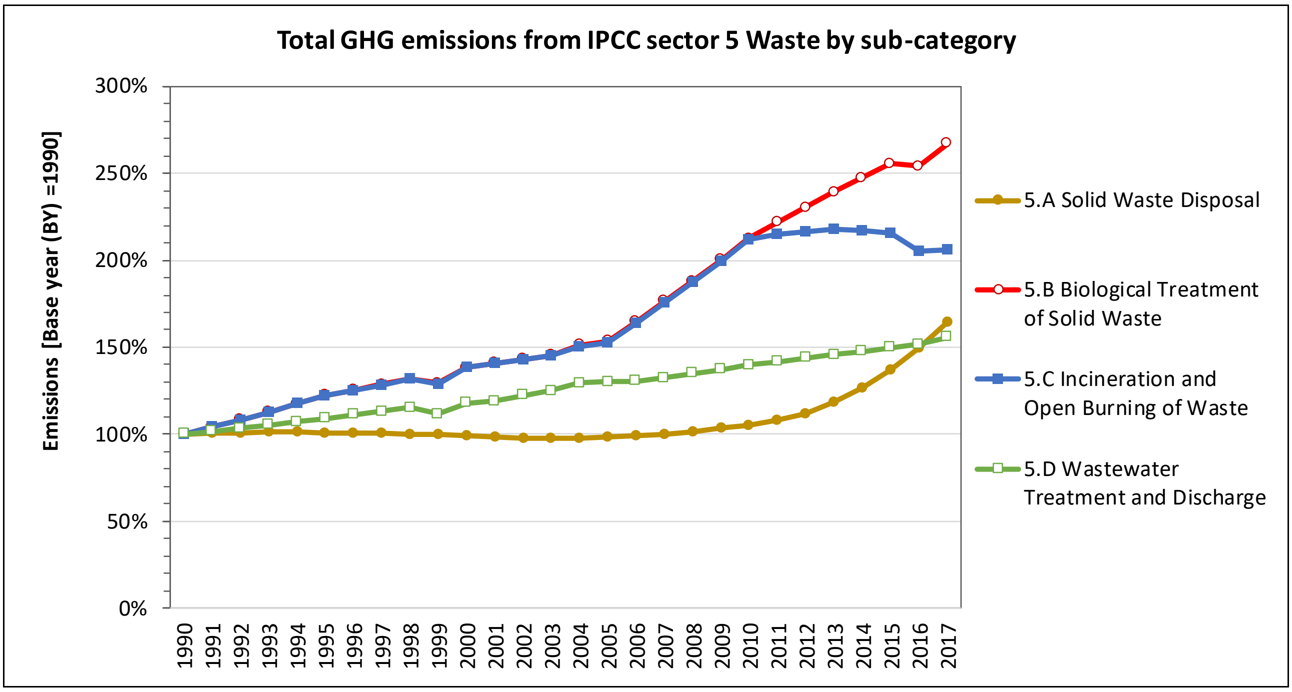


Figure 47 Trend in CO_2 emissions 1990–2017 in index form (base year = 100) of sector 5 Waste

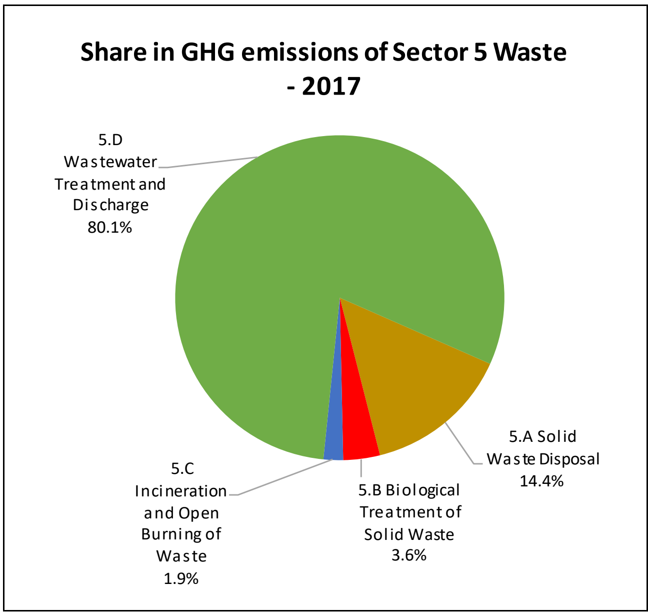


Figure 48 Share in GHG emissions of IPCC sector 5 Waste in 2017

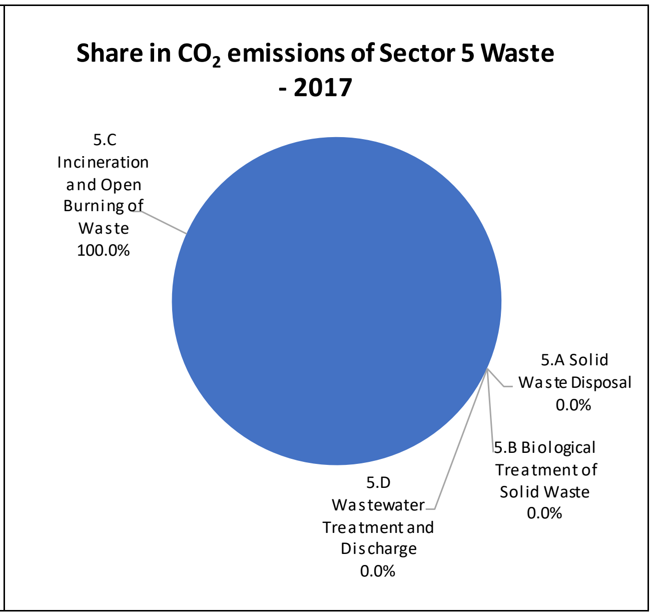


Figure 49 Share in CO_2 emissions of IPCC sector 5 Waste in 2017

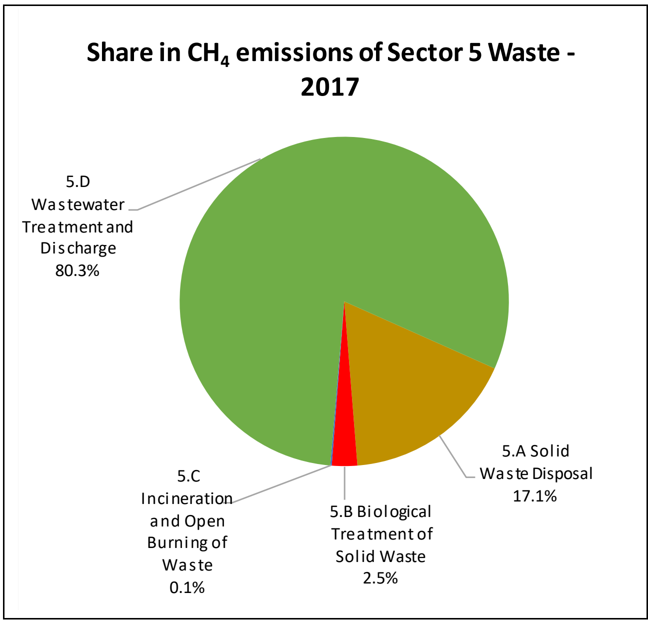


Figure 50 Share in CH_4 emissions of IPCC sector 5 Waste in 2017

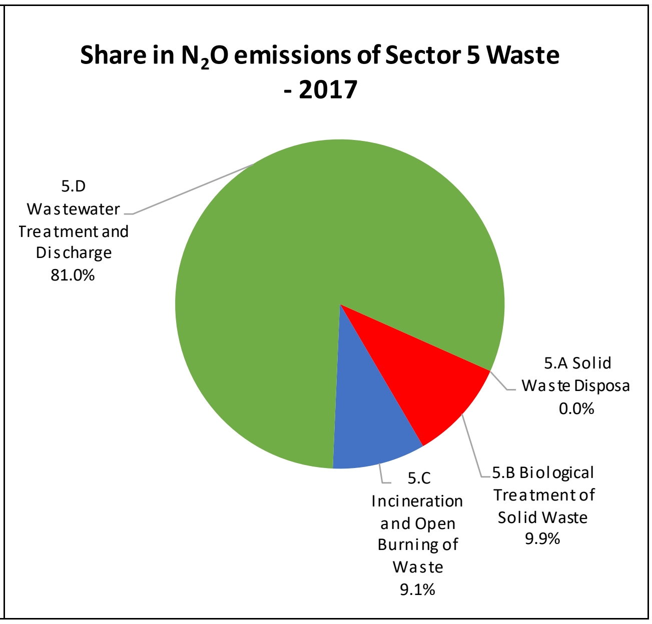


Figure 51 Share in N_2O emissions of IPCC sector 5 Waste in 2017

Table 49 Emissions of GHG of IPCC Sector 4 Waste for 1990, 2000, 2005, 2010, 2012 and 2015- 2017

Greenhouse gas source and sink categories		1990	2000	2005	2010	2012	2015	2016	2017	Trend		
										1990 - 2017	1990 - 2017	1990 - 2017
Greenhouse gas emissions (GHG)												
5	**Waste**	3.03	4.19	4.63	6.41	6.56	6.53	6.22	6.25	**106.2%**	**35.0%**	**0.4%**
5.A	Solid Waste Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
5.B	Biological Treatment of Solid Waste	NA	NA	NA	NA	NA	NA	NA	NA			
5.C	Incineration and Open Burning of Waste	3.03	4.19	4.63	6.41	6.56	6.53	6.22	6.25	**106.2%**	**35.0%**	**0.4%**
5.D	Wastewater Treatment and Discharge	NA	NA	NA	NA	NA	NA	NA	NA			
Total national GHG emissions (without LULUCF)		**18,076.57**	**15,627.54**	**22,453.86**	**36,102.42**	**39,924.62**	**41,995.19**	**42,880.77**	**43,471.39**	**140.5%**	**93.6%**	**1.4%**
CO_2 emissions												
5	**Waste**	3.03	4.19	4.63	6.41	6.56	6.53	6.22	6.25	**106.2%**	**35.0%**	**0.4%**
5.A	Solid Waste Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
5.B	Biological Treatment of Solid Waste	NA	NA	NA	NA	NA	NA	NA	NA			
5.C	Incineration and Open Burning of Waste	3.03	4.19	4.63	6.41	6.56	6.53	6.22	6.25	**106.2%**	**35.0%**	**0.4%**
5.D	Wastewater Treatment and Discharge	NA	NA	NA	NA	NA	NA	NA	NA			
Total national GHG emissions (without LULUCF)		**5,191.09**	**1,855.62**	**4,774.58**	**13,201.51**	**16,770.99**	**18,993.95**	**20,045.39**	**20,934.98**	**303.3%**	**338.5%**	**4.4%**

Greenhouse gas source and sink categories		1990	2000	2005	2010	2012	2015	2016	2017	Trend		
										1990 - 2017	1990 - 2017	1990 - 2017
CH_4 emissions												
5	**Waste**	32.77	38.08	40.64	43.72	45.09	47.97	49.06	50.73	**54.8%**	**24.8%**	**3.4%**
5.A	Solid Waste Disposal	5.27	5.21	5.19	5.55	5.90	7.21	7.88	8.65	**64.3%**	**66.7%**	**9.8%**
5.B	Biological Treatment of Solid Waste	0.47	0.65	0.73	1.00	1.09	1.21	1.20	1.26	**167.1%**	**74.0%**	**5.1%**
5.C	Incineration and Open Burning of Waste	0.04	0.05	0.06	0.08	0.08	0.08	0.07	0.07	**106.2%**	**35.0%**	**0.4%**
5.D	Wastewater Treatment and Discharge	26.99	32.16	34.67	37.09	38.03	39.47	39.91	40.74	**50.9%**	**17.5%**	**2.1%**
Total national GHG emissions (without LULUCF)		**382.37**	**441.47**	**490.22**	**659.68**	**644.39**	**651.91**	**652.50**	**656.74**	**71.8%**	**34.0%**	**0.6%**
N_2O emissions												
5	**Waste**	0.39	0.44	0.56	0.64	0.67	0.71	0.72	0.76	**97.2%**	**37.7%**	**6.6%**
5.A	Solid Waste Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
5.B	Biological Treatment of Solid Waste	0.03	0.04	0.04	0.06	0.07	0.07	0.07	0.08	**167.1%**	**74.0%**	**5.1%**
5.C	Incineration and Open Burning of Waste	0.03	0.05	0.05	0.07	0.07	0.07	0.07	0.07	**106.2%**	**35.0%**	**0.4%**
5.D	Wastewater Treatment and Discharge	0.33	0.36	0.46	0.51	0.53	0.56	0.58	0.62	**90.1%**	**34.5%**	**7.5%**
Total national GHG emissions (without LULUCF)		**11.16**	**9.18**	**18.20**	**21.51**	**23.64**	**22.50**	**21.89**	**20.53**	**83.9%**	**12.8%**	**-6.2%**

Solid waste is generated from households, offices, shops, markets, restaurants, public institutions, industrial installations, water works and sewage facilities, construction and demolition sites, and agricultural activities.

The availability and quality of data on solid waste generation as well as subsequent treatment vary significantly from country to country. In Afghanistan, statistics on waste generation and treatment have been improved substantially during the last 10 years, but there is still gap in comprehensive waste data covering all waste types and treatment techniques. Therefore, an overall analysis was made of the collection process, disposal routes and various treatments techniques. The following steps were done

- Step 1 - Definition of solid waste;
- Step 2 - Waste collection and waste disposal routes: Identification of waste treatments and allocation the waste to the waste treatments;
- Step 3 - Compilation of activity data on waste generation per year starting from 1950;
- Step 4 - Estimation of GHG emission from the different waste treatments techniques.

For estimating CH_4 emission from solid waste disposal (landfilling) data are required for

- waste generation of municipal solid waste (MSW) starting in 1950;
- waste generation of sludge starting in 1950;
- waste generation of industrial waste starting in 1950;
- recycling rate, starting in 1950.

For all other treatment techniques - open burning and/or incineration, composting, anaerobic treatment, mechanical and/or mechanical-biological treatment, data is required for the first inventory year, which was 1990.

2.2.4.1 Solid Waste Disposal (IPCC Subcategory 5.A)

5.A

Solid Waste Disposal

CH_4 emissions occur from the treatment and disposal of municipal, industrial and other solid waste produces. Gas production usually begins 2 months after burial of the wastes and continues up to 100 years. The quantity of CH_4 emitted during decomposition process is directly proportional to the fraction of degradable organic carbon (DOC), which is defined as the carbon content of different types of organic biodegradable wastes such as paper and textiles, garden and park waste, food waste, wood and straw waste. Depending on the waste management practices in the countries, the Municipal Solid Waste Disposal Sites (SWDS) can be divided into Managed SWDS, Unmanaged SWDS, and Uncategorised SWDS.

All landfill sites of Afghanistan were allocated to 'uncategorised waste disposal sites' as the status was not well known. CH_4 emission from 'illegal (wild) landfill sites' were allocated to composting (IPCC category 5.B) as the waste is decomposes mainly aerobically (with oxygen) due to less weight and compactions.

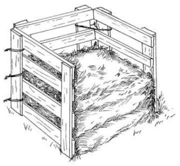
Trend CH_4 emissions increased due to

- growing landfilling activities which was a result of increasing population and growing waste generation rates.
- a reduction of illegal disposal (sites) and open burning.

2.2.4.2 Biological Treatment of Solid Waste (IPCC Subcategory 5.B)

5.B

Biological Treatment of Solid Waste



CH_4 and N_2O emissions occur from 'biological treatment of solid waste' which is either 'composting', 'anaerobic digestion of organic waste' or 'mechanical-biological (MB) treatment'. GHG emissions were estimated only from composting as biogas generation (anaerobic digestion of organic waste) is still not common in Afghanistan.

Composting is an aerobic process and a large fraction of the degradable organic carbon (DOC) in the waste material is converted into carbon dioxide (CO_2). CH_4 is formed in anaerobic sections of the compost, but it is oxidised to a large extent in the aerobic sections of the compost.

Wild landfill sites were allocated to composting (IPCC category 5.B) as the waste decomposition is more comparable to composting (aerobically - with oxygen) then to landfilling (aerobically - without oxygen).

Trend Constantly rising GHG emission are due to increasing waste generation rate because of growing population, composting activities but also still due to backyard dumping and illegal dumping in districts/villages and garbage pit.

2.2.4.3 Open Burning of Waste (IPCC Subcategory 5.C)

5.C Incineration and Open Burning of Waste

GHG emissions occur from combustion of waste either in waste incineration plants or in form of open burning of waste.

5.C.1 Waste Incineration (with or without energy recovery)

5.C.2 Open Burning of Waste

Consistent information about the operation of waste incinerators were not available therefore, this source is not estimated. GHG emission from open burning of waste is estimated.

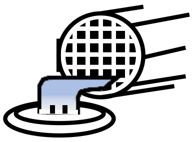
Trend Fluctuation of fuel consumption and emissions are due to

- Increasing population and increased waste generation rate
- Increasing needs of getting rid of the waste
- missing adequate waste management practice.

2.2.4.4 Wastewater Treatment (IPCC Subcategory 5.D)

5.D

Wastewater Treatment and Discharge



CH_4 emissions from wastewater occur when wastewater is treated or disposed anaerobically. Wastewater is also a source of N_2Oemissions. CO_2 emissions from wastewater are not considered because these are of biogenic origin. Wastewater originates from a variety of domestic, commercial and industrial sources and is treated on site (uncollected), sewerage to a centralized plant (collected) or disposed untreated nearby. Domestic wastewater is defined as wastewater from household water use, while industrial wastewater is from industrial practices only.

Migrations from rural to urban, industrial sector and increasing population growth have considerable affection creating wastewater production. In low income countries, like Afghanistan, organization, industrialization, rapid population growth, unplanned urbanization and informal activities are one of the significant issues regarding wastewater and water pollution. Due to the high methane generation potential of wastewater from latrines, this category is an important GHG source in Afghanistan.

Trend The reason for the steadily rising GHG emissions is the growing population. However, the improved sanitations facilities in urban areas did not counterbalance the rising trend.

3 Energy (IPCC sector 1)

3.1 Sector Overview

In the Energy Sector, emissions originating from fuel combustion activities in road traffic, in the energy and manufacturing industry and in the commercial, agricultural and residential sector (Category 1.A) as well as fugitive emissions from fuels (Category 1.B) are considered. However, fugitive emissions make up less than 1% of the total emissions from this sector.

Emissions from the Energy Sector are the main source of GHGs in Afghanistan:

- in 1990 about 29.1% of the total national GHG emissions and 92.8% of total CO_2 emissions arose from the energy sector, whereas N_2O and CH_4 emissions only make up about 1.8% and 5.5%, respectively.
- in 2005 about 22.6% of the total national GHG emissions and 90.5% of total CO_2 emissions arose from the energy sector, whereas N_2O and CH_4 emissions only make up about 1.9% and 7.5%, respectively.
- in 2017 about 49.8% of the total national GHG emissions and 95.2% of total CO_2 emissions arose from the energy sector, whereas N_2O and CH_4 emissions only make up about 1.2% and 3.6%, respectively.

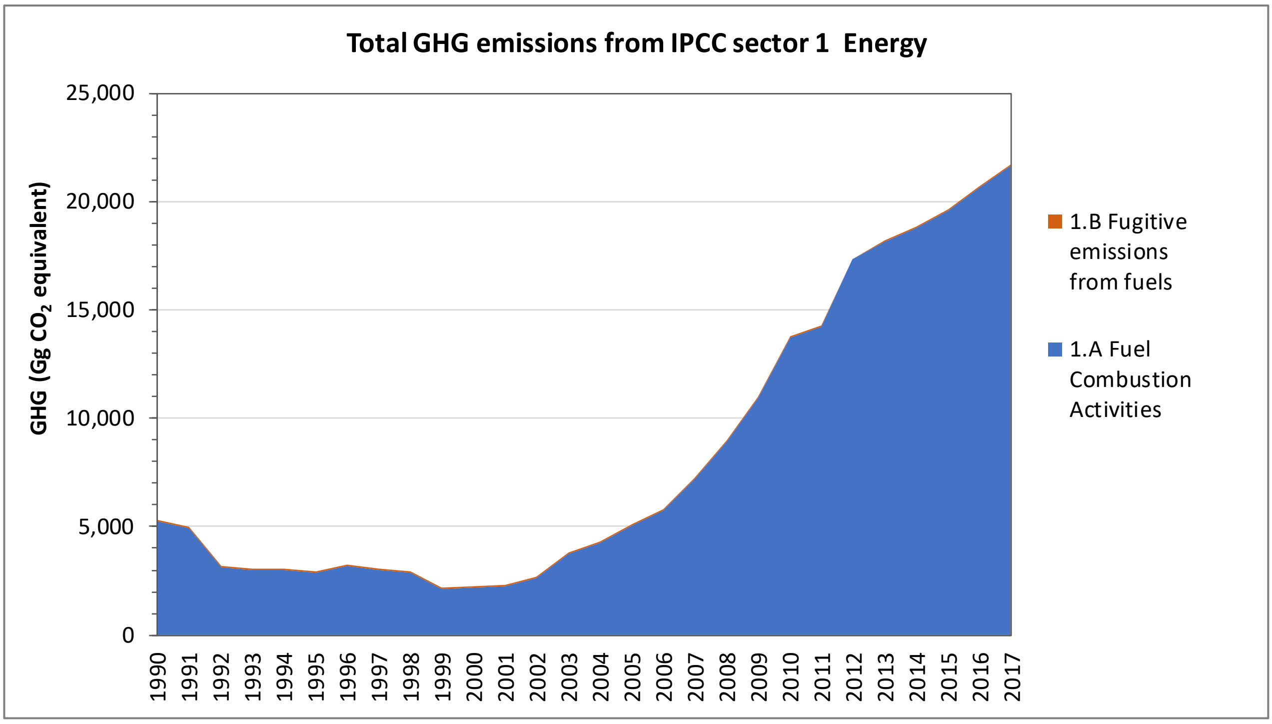


Figure 52 Trend of GHG emissions from 1990 – 2017 for energy

Emission trends

In the period 1990 to 2017 GHG emissions from the Energy Sector increased by 311% from 5,267.65 Gg CO_2 eq in 1990 to 21,649.43 Gg CO_2 eq in 2017. Emissions from the energy sector decreased by 3.8% from 5,267.65 Gg CO_2 equivalents in 1990 to 5,066.98 Gg CO_2 equivalents in 2005. In the period 2005 to 2017 GHG emissions from the energy sector increased by 327% from 5,066.98 Gg CO_2 equivalents in 2005 to 21,649.43 Gg CO_2 equivalents in 2017. The increase of emissions is mainly caused by increasing emissions from fuel combustion in *Transport* (IPCC subcategory 1.A.3) and in *Manufacturing industries and construction* (IPCC subcategory 1.A.2).

In the period 2016 to 2017 GHG emissions from the Energy Sector increased by 1.4% from 20,664.69 Gg CO_2 eq in 2016 to 21,649.43 Gg CO_2 eq in 2017, which is mainly caused by increasing emissions from fuel combustion in *Manufacturing industries and construction* (IPCC subcategory 1.A.2).

The most important sources of GHGs in the Energy Sector is *Transport* and *Manufacturing Industries and Construction*. With regards to CO_2 emission, the source *Transport* was the primary source.

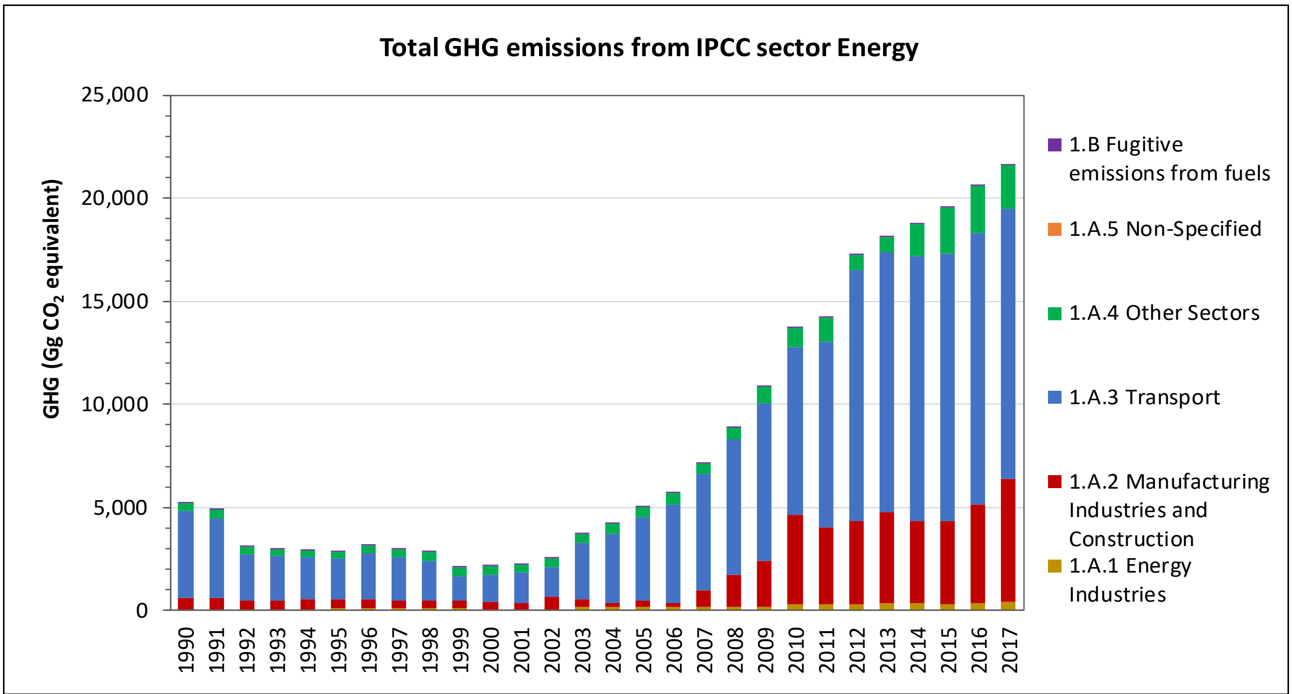


Figure 53 **Total national GHG emissions by category of sector Energy (1990-2017)**

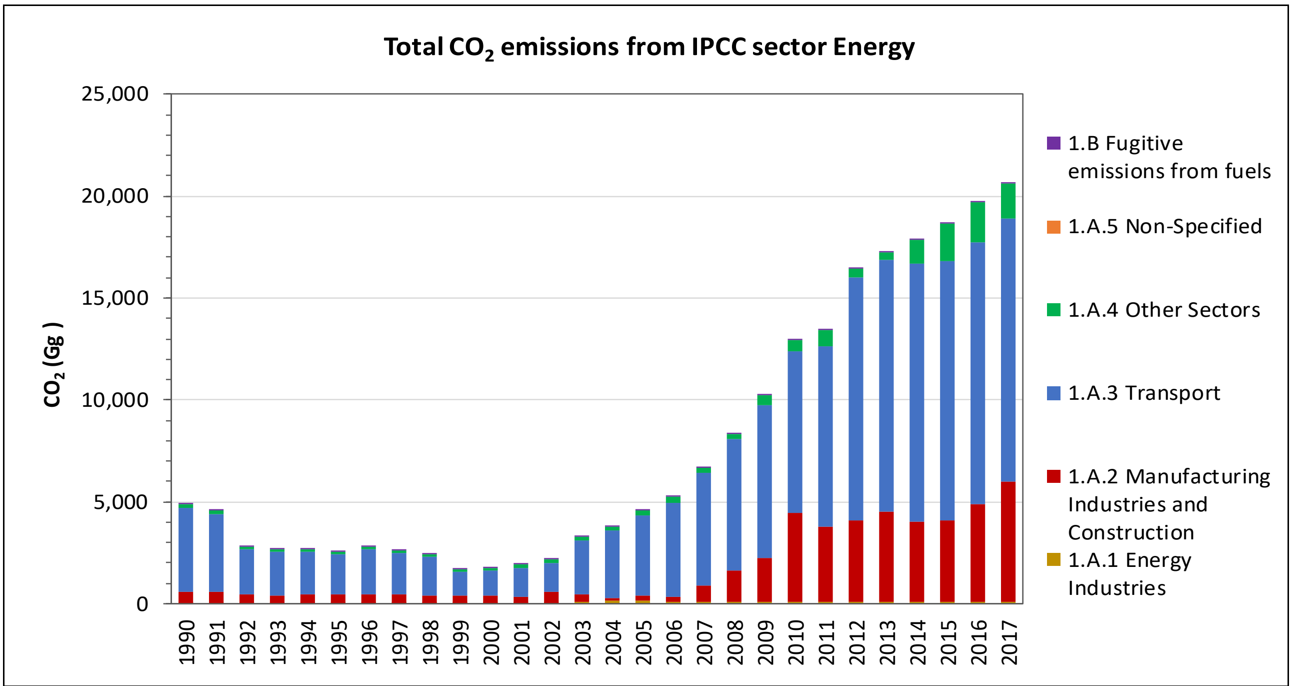


Figure 54 **Total national CO_2 emissions by category of sector Energy (1990-2017)**

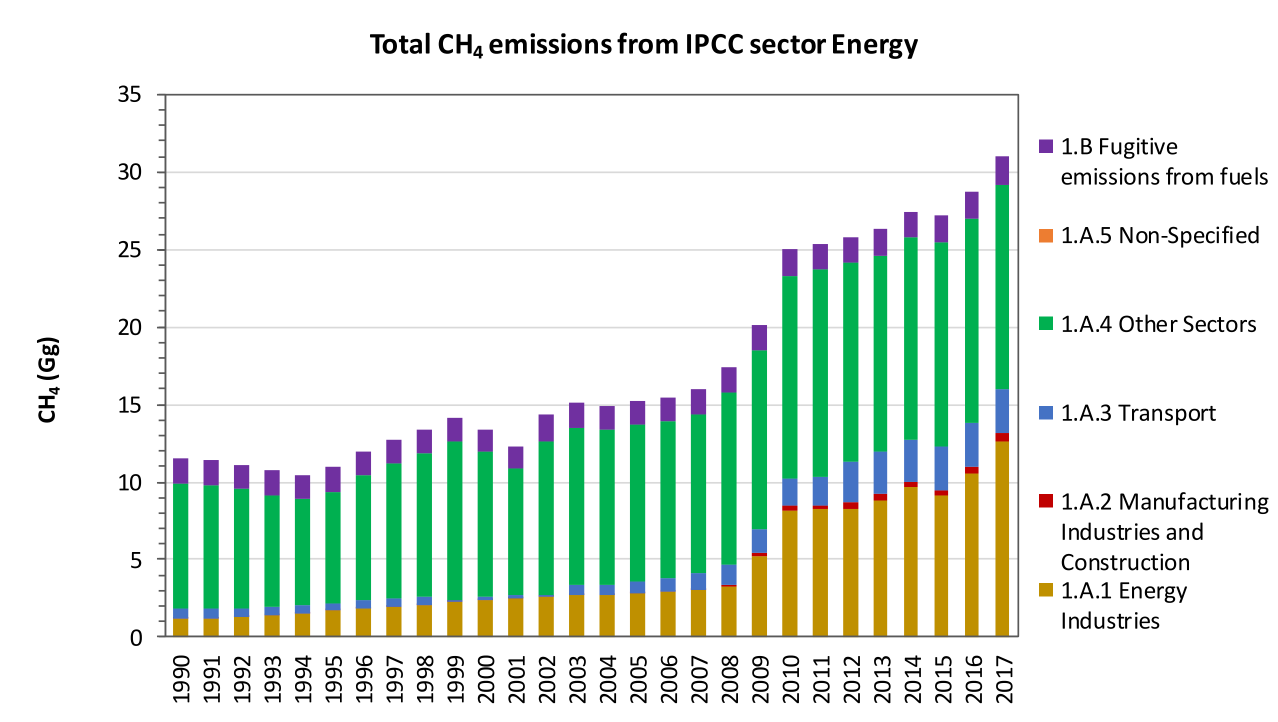


Figure 55 **Total national CH_4 emissions by category of sector Energy (1990-2017)**

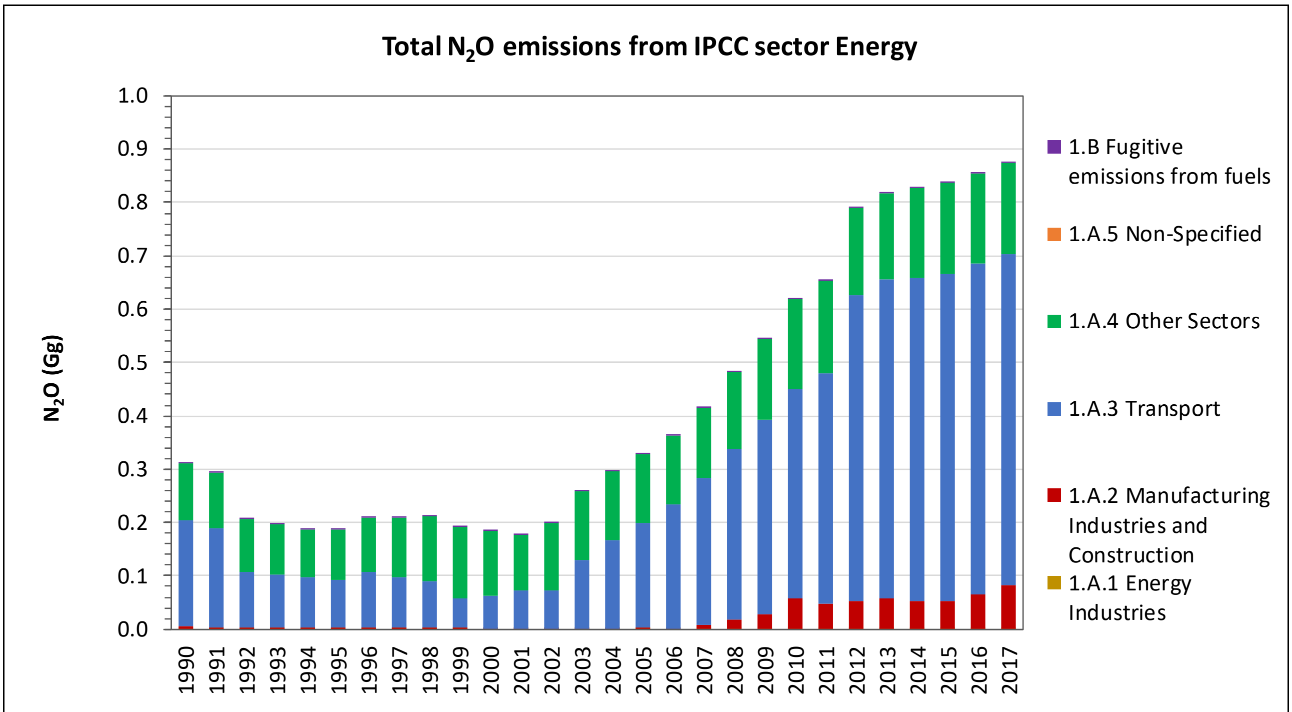


Figure 56 **Total national N_2O emissions by category of sector Energy**

Table 50 Emissions from IPCC sub-category 1 Energy: 1990 - 2017

GHG emissions	**TOTAL GHG** (excluding biomass)	**CO_2** (excluding biomass)	**CH_4** (including biomass)	**N_2O** (including biomass)	**CH_4** (including biomass)	**N_2O** (including biomass)	**MEMO ITEM CO_2** (biomass)
	Gg CO_2 equivalent	**Gg**	**Gg** CO_2 equivalent	**Gg** CO_2 equivalent	**Gg**	**Gg**	**Gg**
1990	5,267.65	4,886.21	288.73	92.71	11.55	0.31	2,648.29
1991	4,937.88	4,565.49	284.70	87.69	11.39	0.29	2,597.81
1992	3,147.85	2,807.67	278.45	61.73	11.14	0.21	2,518.25
1993	3,028.04	2,701.61	268.18	58.25	10.73	0.20	2,351.30
1994	2,981.32	2,663.62	262.22	55.48	10.49	0.19	2,238.68
1995	2,901.09	2,571.45	274.07	55.57	10.96	0.19	2,359.50
1996	3,198.22	2,836.91	298.72	62.60	11.95	0.21	2,619.17
1997	3,001.22	2,620.01	318.62	62.59	12.74	0.21	2,856.65
1998	2,862.16	2,464.63	334.66	62.87	13.39	0.21	3,050.84
1999	2,132.09	1,722.10	352.87	57.12	14.11	0.19	3,382.56
2000	2,178.63	1,788.28	335.57	54.77	13.42	0.18	3,091.05
2001	2,273.73	1,912.71	308.26	52.75	12.33	0.18	2,683.40
2002	2,598.96	2,181.98	357.91	59.07	14.32	0.20	3,248.29
2003	3,747.32	3,290.71	379.21	77.40	15.17	0.26	3,338.11
2004	4,264.20	3,802.87	373.02	88.31	14.92	0.30	3,334.95
2005	5,066.98	4,587.71	381.27	98.00	15.25	0.33	3,341.17
2006	5,736.67	5,241.66	386.66	108.36	15.47	0.36	3,326.77
2007	7,191.20	6,669.05	398.48	123.67	15.94	0.42	3,350.35
2008	8,947.55	8,368.05	435.85	143.65	17.43	0.48	3,653.77
2009	10,935.03	10,269.67	503.23	162.12	20.13	0.54	3,778.08
2010	13,749.13	12,939.46	624.96	184.71	25.00	0.62	4,295.94
2011	14,253.71	13,424.79	634.09	194.83	25.36	0.65	4,343.47
2012	17,324.81	16,443.91	645.36	235.54	25.81	0.79	4,168.42
2013	18,155.72	17,253.01	658.94	243.77	26.36	0.82	4,111.53
2014	18,784.66	17,852.65	685.54	246.46	27.42	0.83	4,185.72
2015	19,614.68	18,685.63	679.60	249.45	27.18	0.84	4,234.56
2016	20,664.69	19,692.65	717.39	254.65	28.70	0.85	4,218.94
2017	21,649.43	20,615.03	773.94	260.45	30.96	0.87	4,230.35
Trend 1990 - 2017	*311.0%*	*321.9%*	*168.1%*	*180.9%*	*168.1%*	*180.9%*	*59.7%*
Trend 2005 - 2017	*327.3%*	*349.4%*	*103.0%*	*165.8%*	*103.0%*	*165.8%*	*26.6%*
Trend 2012 - 2017	*25.0%*	*25.4%*	*19.9%*	*10.6%*	*19.9%*	*10.6%*	*1.5%*
Trend 2016 - 2017	*4.8%*	*4.7%*	*7.9%*	*2.3%*	*7.9%*	*2.3%*	*0.3%*

Remark: MEMO ITEM: CO_2 (biomass): CO_2 from Biomass Combustion for Energy Production

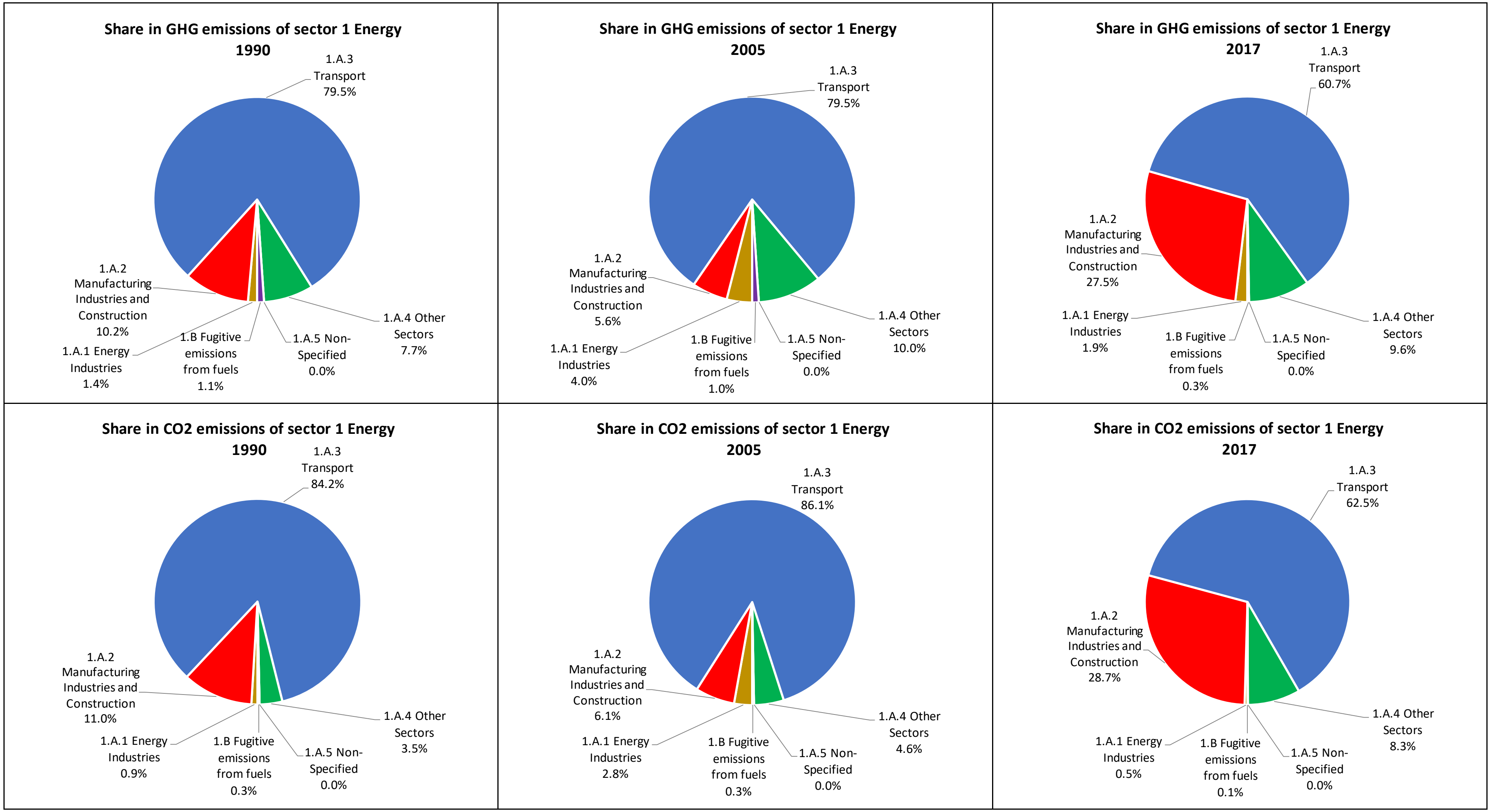


Figure 57 Share of GHG and CO_2 emissions in Sector 1 Energy in 1990, 2005 and 2017

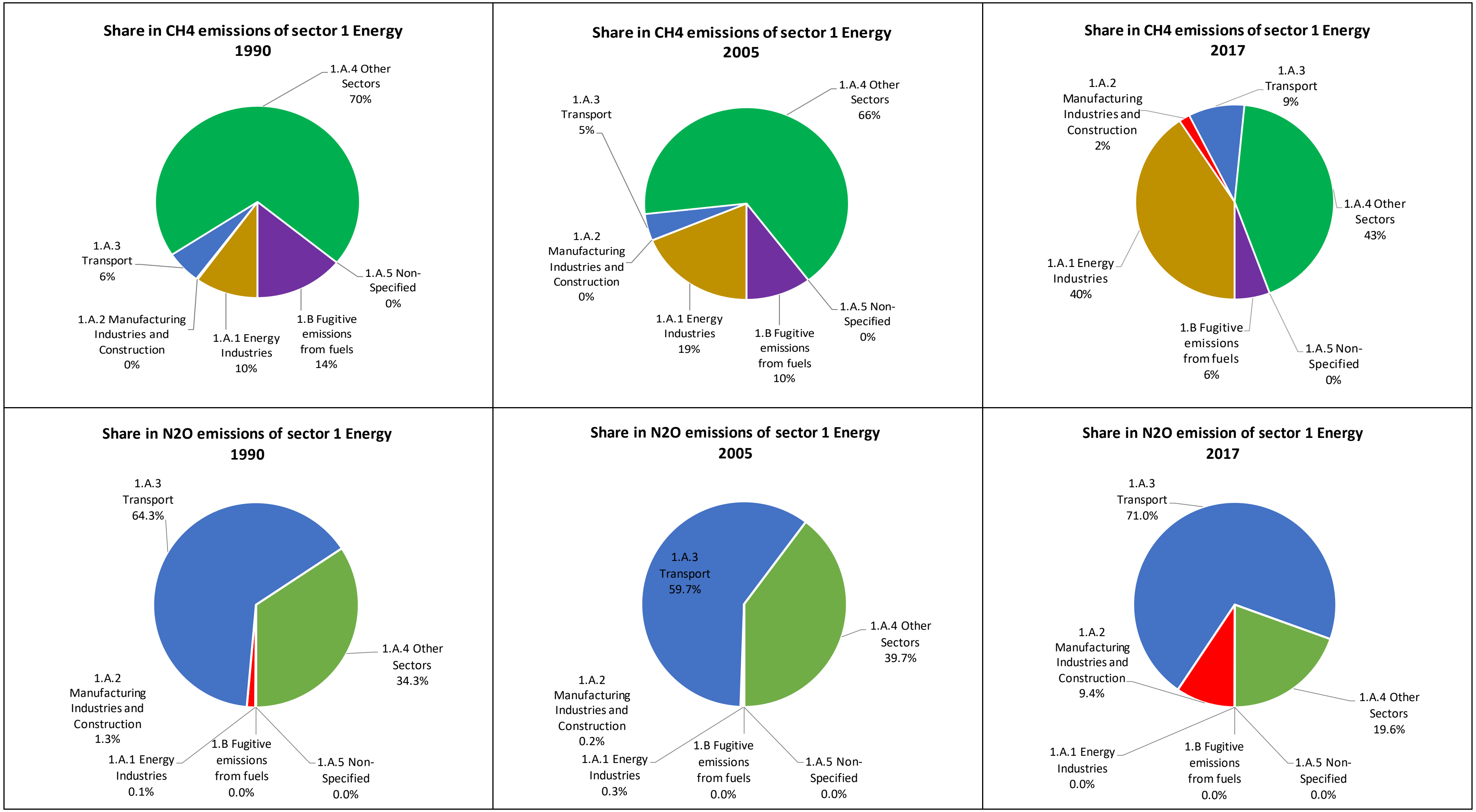


Figure 58 Share of CH_4 and N_2O emissions in Sector 1 Energy in 1990, 2005 and 2017

Table 51 GHG Emissions from IPCC sub-category 1 Energy by sub-categories: 1990 - 2017

GHG emissions	1 Energy	1.A Fuel Combustion Activities	1.A.1 Energy Industries	1.A.2 Manufacturing Industries and Construction	1.A.3 Transport	1.A.4 Other Sectors	1.A.5 Non-Specified	1.B Fugitive emissions from fuels	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg CO_2 equivalent									
1990	5,267.65	5,211.22	74.65	538.80	4,190.11	407.66	NE	56.43	32.73	23.70
1991	4,937.88	4,882.13	72.51	523.54	3,888.31	397.76	NE	55.75	32.70	23.05
1992	3,147.85	3,093.85	74.84	394.30	2,268.88	355.83	NE	54.00	32.52	21.48
1993	3,028.04	2,974.74	77.78	385.40	2,172.52	339.04	NE	53.30	32.52	20.79
1994	2,981.32	2,928.82	78.02	447.17	2,076.53	327.10	NE	52.50	32.51	19.99
1995	2,901.09	2,849.39	81.54	442.18	1,986.77	338.89	NE	51.70	32.51	19.18
1996	3,198.22	3,147.39	85.29	436.76	2,264.41	360.93	NE	50.83	32.51	18.33
1997	3,001.22	2,951.82	85.99	412.12	2,072.57	381.13	NE	49.40	32.50	16.90
1998	2,862.16	2,813.91	88.78	391.90	1,932.07	401.16	NE	48.26	32.50	15.75
1999	2,132.09	2,084.98	85.80	372.31	1,200.97	425.90	NE	47.11	32.50	14.61
2000	2,178.63	2,132.61	67.30	374.35	1,289.07	401.89	NE	46.02	32.50	13.52
2001	2,273.73	2,228.51	66.27	303.95	1,490.10	368.19	NE	45.22	32.56	12.66
2002	2,598.96	2,534.10	68.51	606.37	1,439.17	420.05	NE	64.86	32.55	32.32
2003	3,747.32	3,687.23	163.56	381.97	2,710.72	430.98	NE	60.09	32.58	27.52
2004	4,264.20	4,217.84	201.06	170.16	3,370.92	475.70	NE	46.36	32.57	13.79
2005	5,066.98	5,014.71	200.44	281.90	4,027.38	504.99	NE	52.27	32.57	19.70
2006	5,736.67	5,684.95	148.28	236.41	4,755.08	545.19	NE	51.72	32.58	19.15
2007	7,191.20	7,139.77	167.59	784.89	5,679.96	507.32	NE	51.43	33.03	18.40
2008	8,947.55	8,895.04	166.43	1,538.40	6,614.39	575.82	NE	52.51	33.59	18.92

GHG emissions	1 Energy	1.A Fuel Combustion Activities	1.A.1 Energy Industries	1.A.2 Manufacturing Industries and Construction	1.A.3 Transport	1.A.4 Other Sectors	1.A.5 Non-Specified	1.B Fugitive emissions from fuels	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg CO_2 equivalent									
2009	10,935.03	10,883.98	193.58	2,220.11	7,631.50	838.79	NE	51.05	34.08	16.97
2010	13,749.13	13,696.92	296.63	4,372.45	8,094.18	933.67	NE	52.21	35.72	16.49
2011	14,253.71	14,199.83	299.17	3,720.09	8,991.74	1,188.83	NE	53.88	35.20	18.68
2012	17,324.81	17,270.70	301.92	4,040.54	12,156.56	771.67	NE	54.11	35.43	18.68
2013	18,155.72	18,101.34	334.93	4,405.10	12,649.52	711.79	NE	54.39	35.80	18.58
2014	18,784.66	18,732.09	341.15	3,979.55	12,880.92	1,530.47	NE	52.56	35.47	17.09
2015	19,614.68	19,561.77	292.41	4,040.48	13,015.30	2,213.58	NE	52.91	35.51	17.40
2016	20,664.69	20,609.17	336.20	4,816.94	13,136.61	2,319.42	NE	55.52	36.20	19.33
2017	21,649.43	21,593.37	408.05	5,962.76	13,136.61	2,085.95	NE	56.05	37.27	18.78
Trend 1990 - 2017	*311.0%*	*314.4%*	*446.6%*	*1006.7%*	*213.5%*	*411.7%*	*NA*	*-0.7%*	*13.9%*	*-20.7%*
Trend 2005 - 2017	*327.3%*	*330.6%*	*103.6%*	*2015.2%*	*226.2%*	*313.1%*	*NA*	*7.2%*	*14.4%*	*-4.7%*
Trend 2012 - 2017	*25.0%*	*25.0%*	*35.2%*	*47.6%*	*8.1%*	*170.3%*	*NA*	*3.6%*	*5.2%*	*0.5%*
Trend 2016 - 2017	*4.8%*	*4.8%*	*21.4%*	*23.8%*	*0.0%*	*-10.1%*	*NA*	*1.0%*	*3.0%*	*-2.8%*

3.2 Fuel Combustion Activities (IPCC sector 1.A)

3.2.1 Comparison of the sectoral approach with the reference approach

A comparison of the sectoral approach with the reference approach was carried out. No quantitative information of the result of the comparison of the sectoral approach with the reference approach are provided due to the below mentioned various aspects. However, the quality assurance (QA) exercise was performed and identified relevant aspects for differences:

(A) National energy balance provided by NSIA

- Data on sectoral level not available
    - only national total of national production;
    - only Totals of fuel imported / exported;
- Not all fuels included, e.g. national input and output of refineries;
- Fuel type and fuel characteristics as well as related net caloric value (NCV) not available, e.g. coal
- Natural gas: No split in energy use and non-energy use; for this inventory the split was calculated based on the urea and ammonia production;
- Fuel consumption of renewables – biomass fraction - such as wood, wood waste, charcoal, dung, and residual waste is not well known and for this inventory the first time estimated;
- Fuel consumption of renewable – biomass fraction, such as residual waste, waste oil, tires, is not well known and for this inventory the first time estimated;

(B) National energy balance provided by UN statistics

- Data on sectoral level available but with partly wrong allocation, e. g. public electricity production based on liquid fuels
- Not all fuels included, e.g. national input and output of refineries;
- Data on sectoral level are mainly based on estimates made UN energy statistics division.

(C) Black market dealing of fuels, e.g. road transport

The *International Recommendations for Energy Statistics* (IRES)[42], which provide a comprehensive methodological framework for the collection, compilation and dissemination of energy statistics in all countries irrespective of the level of development of their statistical system, is stated in Chapter XI. Uses of basic energy statistics and balances, Section D. Greenhouse gas emissions

11.34 The availability of good, reliable and timely basic energy statistics and energy balances is fundamental for the estimation of greenhouse gas (GHG) emissions and to address the global concerns for climate change. **Basic energy statistics and energy balances are the main sources of data for the calculation of energy-related GHG emissions**, as the IPCC Guidelines are based on the same conceptual framework. Countries are encouraged to make additional efforts to verify the compiled data and make any necessary adjustments to ensure that the calculated emissions are internationally comparable.

[…]

11.45 Regardless of the Tier used, consumption of fuels by fuel/product type is the very first basic step in the estimation of CO_2 emissions from fuel combustion. <u>If this basic step is not done properly, the</u>

[42] United Nation (UN) (2018): International Recommendations for Energy Statistics (IRES): ST/ESA/STAT/SER.M/93. Available (25 November 2018) on https://unstats.un.org/unsd/energy/ires/IRES-web.pdf

subsequent steps cannot result in an accurate estimate. Data on the production and consumption of fuels and energy products are part of national energy statistics, normally in the form of national energy balances. **It is therefore unequivocal that the quality of GHG estimates depends critically on the quality of national energy statistics.** This dependence is fully recognized by the IPCC Guidelines, which encourage the use of fuel statistics collected by official national bodies, as this usually provides the most appropriate and accessible data.

11.46 If national data sources are unavailable or have gaps, IPCC suggests using data from international organizations (based normally on national submissions from countries). The two main sources of international energy statistics are the United Nations Statistics Division (UNSD) and the International Energy Agency (IEA). Both collect data from the national administrations of their member countries through questionnaires (thus collecting “official data”) and they exchange data to ensure consistency and prevent duplication of efforts by reporting countries.

11.47 Estimating non-CO_2 emissions from fuel combustion normally requires more specific methods than for CO_2 emissions and more detailed information, such as the characteristics of fuel composition, combustion conditions, combustion technologies and emission control methods. Specific methods and data are also used for estimating fugitive CO_2 and non-CO_2 emissions. Such methods and associated data requirements can be found in the corresponding sections of the IPCC Guidelines. **It is quite clear also in the Guidelines that for these emissions national energy statistics are indispensable for obtaining a solid emissions estimate.**

However, for the preparation of energy statistics and national energy balance are required sufficient resources and suitable institutional arrangements in order to

(1) map the energy flow,

(2) develop data collection strategies, and

(3) implement data quality assurance activities, and finally to

(4) collect, to compile and to disseminate.

3.2.2 International bunker fuels

3.2.2.1 International aviation

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
1.A.3.a	Civil Aviation						
1.A.3.a.i	International Aviation (International Bunkers)	✓	NA	✓	NA	✓	NA

Emissions from aviation come from the combustion of jet fuel (jet kerosene and jet gasoline) and aviation gasoline. As stated in the 2006 IPCC Guidelines, Vol. 2, Chap. 3 aircraft engine emissions are roughly composed of about 70 percent CO_2, a little less than 30 percent H2O, and less than 1 percent each of NOx, CO, SOx, NMVOC, particulates, and other trace components including hazardous air pollutants. Little or no N_2O emissions occur from modern gas turbines (IPCC, 1999). Methane (CH_4) may be emitted by gas turbines during idle and by older technology engines, but recent data suggest that little or no CH_4 is emitted by modern engines.

Emissions depend on the

- number and type of aircraft operations;
- types and efficiency of the aircraft engines;
- fuel used;
- length of flight;
- power setting; spent at each stage of flight;
- altitude at which exhaust gases are emitted.

3.2.2.1.1 Source category description

Air transport in Afghanistan is provided by four international airports, where Kabul International Airport being the country's busiest airport. For domestic air transport are available 3 major domestic airports, 18 regional domestic airports 20 small local airports, and 3 military airports.

Table 52 International Airports across Afghanistan

City served	Airport name	Province	ICAO code	IATA code
Kabul	Hamid Karzai International Airport	Kabul	OAKB	KBL
Herat	Herat International Airport	Herat	OAHR	HEA
Kandahar	Kandahar International Airport	Kandahar	OAKN	KDH
Mazar-i-Sharif	Mazar-i-Sharif International Airport	Balkh	OAMS	MZR

Source: ASIAN DEVELOPMENT BANK (2017): Afghanistan Transport Sector Master Plan Update (2017–2036). Philippines.[43]

In the period 1990 to 2017 GHG emissions from the IPCC category 1.A.3.a.i *International Aviation* decreased by -55.2% from 400.68 Gg CO_2 eq in 1990 to 179.35 Gg CO_2 eq in 2017. In the period 2005 to 2017 GHG emissions from the IPCC category 1.A.3.a.i *International Aviation* increased by 2.5% from 174.90 Gg CO_2 eq

[43] Available (18.12.2018) at https://www.adb.org/documents/afg-transport-plan-update-2017-2036

in 2005 to 179.35 Gg CO_2 eq in 2017. In the period 2016 to 2017 GHG emissions from the IPCC category 1.A.3.a.i *International Aviation* remain stable.

The decrease in GHG emissions and the annual fluctuations of the emissions are due to decreased fuel consumption in this sector mainly due to the Afghan Civil War (1989–92, 1996–2001) and War in Afghanistan (2001–present).

In the following tables fuel consumption and emission from IPCC sub-category 1.A.3.a.i *International Aviation*. Fuel consumption and emission from IPCC sub-category 1.A.3.a.ii Domestic Aviation are presented in Chapter 3.2.7.1

Table 53 Activity data and GHG emissions for IPCC sub-category 1.A.3.a.i International Aviation

	Activity data		Emission			
	Kerosene-type Jet Fuel	Aviation gasoline	GHG	CO_2	CH_4	N_2O
	TJ		Gg $_{CO2\ equivalent}$			
1990	264.60	NO	400.68	397.30	0.07	3.31
1991	264.60	NO	368.88	365.77	0.06	3.05
1992	264.60	NO	263.94	261.71	0.05	2.18
1993	264.60	NO	257.58	255.41	0.04	2.13
1994	220.50	NO	251.22	249.10	0.04	2.08
1995	220.50	NO	238.50	236.49	0.04	1.97
1996	220.50	NO	222.60	220.72	0.04	1.84
1997	220.50	NO	206.70	204.95	0.04	1.71
1998	220.50	NO	193.98	192.34	0.03	1.60
1999	220.50	NO	174.90	173.42	0.03	1.45
2000	220.50	NO	168.54	167.12	0.03	1.39
2001	220.50	NO	159.00	157.66	0.03	1.31
2002	220.50	NO	143.10	141.89	0.02	1.18
2003	352.80	NO	127.20	126.13	0.02	1.05
2004	441.00	NO	165.36	163.96	0.03	1.37
2005	441.00	NO	174.90	173.42	0.03	1.45
2006	441.00	NO	174.90	173.42	0.03	1.45
2007	441.00	NO	181.26	179.73	0.03	1.50
2008	441.00	NO	197.16	195.50	0.03	1.63
2009	441.00	NO	295.74	293.24	0.05	2.44
2010	441.00	NO	101.76	100.90	0.02	0.84
2011	441.00	NO	190.80	189.19	0.03	1.58
2012	441.00	NO	162.18	160.81	0.03	1.34
2013	441.00	NO	162.18	160.81	0.03	1.34
2014	445.41	NO	163.77	162.39	0.03	1.35

	Activity data		Emission			
	Kerosene-type Jet Fuel	Aviation gasoline	GHG	CO_2	CH_4	N_2O
	TJ		Gg CO2 equivalent			
2015	436.59	NO	179.67	178.15	0.03	1.49
2016	441.00	NO	179.35	177.84	0.03	1.48
2017	441.00	NO	179.35	177.84	0.03	1.48
Trend						
1990 - 2017	*-55.2%*	-	*-55.2%*	*-55.2%*	*-55.2%*	*-55.2%*
2005 - 2017	*2.5%*	-	*2.5%*	*2.5%*	*2.5%*	*2.5%*
1990 - 2017	*0.0%*	-	*0.0%*	*0.0%*	*0.0%*	*0.0%*

3.2.2.1.2 Methodological Issues

Emissions have been calculated using TIER 1 methodology of 2006 IPCC guidelines, Vol. 2, Chap. 3, as described in Chapter 3.2.7.1 Civil Aviation (IPCC subcategory 1.A.3.a).

3.2.2.2 International navigation

Afghanistan is a landlocked country. Inland waterways are limited to Amu Darya and the Panj River. The only river port is Shir Khan Bandar. The Afghan border town is a dry port, where the port terminal is directly connected with road and rail for un- and upload.

The national and international energy balance does not provide data on fuel consumption for international navigation.

3.2.3 Feedstocks and non-energy use of fuels

Natural gas is used as feedstock in the fertilizer plant. The emissions are estimated in IPCC subcategory 2.B.1 *Ammonia Production*. Methodology and activity data are described in chapter 4.2.1.

Lubricants are used as non-energy product. The related emissions are estimated in IPCC category 2.D *Non-Energy Products from Fuels and Solvent Use*. Methodology and activity data are described in chapter 4.4.

3.2.4 Country-specific issues

3.2.4.1 Electricity and heat production

The first electricity station of Afghanistan with a capacity of 40 lights was built in 1893 in the capital of Afghanistan (Kabul). Post-conflict efforts are made by Afghanistan and international donors to focus on expanding the availability of energy resources throughout the country.[44] However, Afghanistan's energy infrastructure, generation, transmission and distribution were almost destroyed over the past three decades due to war and conflict. In 2006, 19 out of 45 power plants were not operational, while by 2011, only eight out of 45 did not produce power.[45]

[44] Sayed Shah Danish (2017): Electricity Sector Development Trends in an After-war Country: Afghanistan Aspiration for an Independent Energy Country. Available (28 January 2019) on https://www.researchgate.net/publication/319957923_Electricity_Sector_Development_Trends_in_an_After-war_Country_Afghanistan_Aspiration_for_an_Independent_Energy_Country

[45] Source: DABS (2014): Afghanistan's Energy Report. Available (28 January 2019) on https://eneken.ieej.or.jp/data/5585.pdf

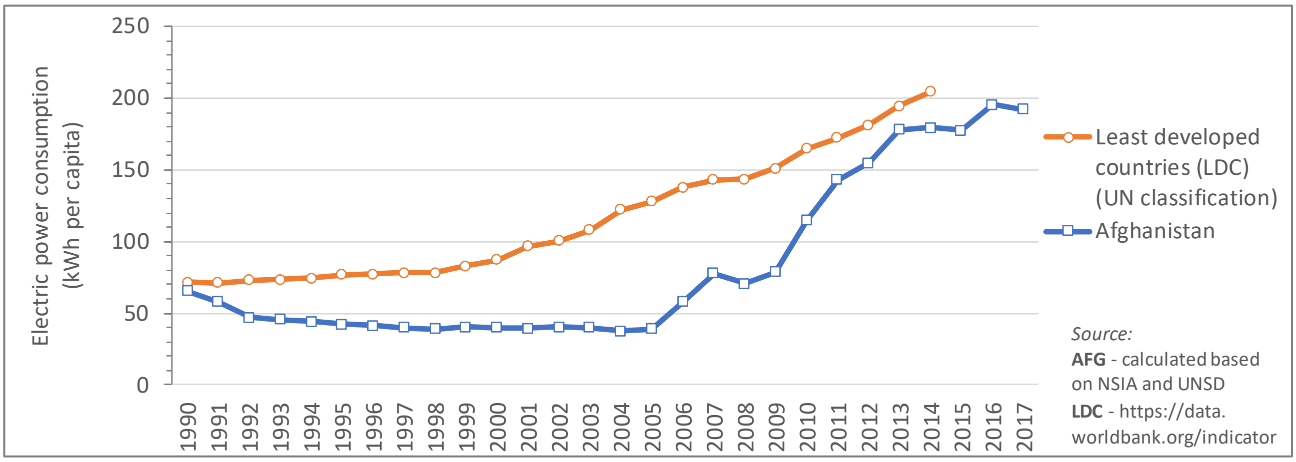


Figure 59 Electric power consumption (kWh per capita) in Afghanistan and LDC

As shown in the figure above Afghanistan energy consumption is lowest amongst the world, the electricity consumption per capita per year was in 2017 around 192 kWh (kilo-watt-hours). According to the National Risk and Vulnerability Assessment (NRVA) 2007/2008 the access to the public electric grid at national level was 20 % (ranging from 78 % in urban areas to 6 % in rural areas). Overall, 42 % of the population has access to any source of electricity (90 % and 33 % in urban and rural areas, respectively). According to the Afghanistan Living Conditions Survey (ALCS) 2016-2017, the access to the public electric grid at national level was 31 % (ranging from 92 % in urban areas to 13 % in rural areas). Overall, 98 % of the population has access to any source of electricity (90 and 33 percent in urban and rural areas, respectively).

Table 54 Population, by residence, and by access to different sources of electricity in the last month

	Any source	Electric grid	Govern-mental generator	Private		Community		Solar	Wind	Battery
				generator	Dynamo	generator	dynamo			
Total	97.7%	30.9%	0.2%	1.4%	1.0%	0.5%	6.7%	59.4%	0.5%	10.8%
Urban	99.5%	91.9%	0.5%	4.2%	0.2%	0.2%	0.1%	15.7%	0.2%	7.9%
Rural	97.8%	12.7%	0.1%	0.6%	1.4%	0.7%	9.3%	73.2%	0.6%	11.3%
Kuchi	86.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	70.8%	0.3%	17.1%

Source: CSO/NSIA (2018): Afghanistan Living Conditions Survey 2016-2017. Kabul.

In the last decade focus has been put on[44]

- expanding and rehabilitating the electricity sector;
- energy loss reduction;
- hydro-electric generation,
- rehabilitating and expanding electricity generation factories,
- developing renewable energy resources – wind and solar - in rural and remote areas,
- increasing low-cost power imports, and
- improving the capability of energy sector institutions.

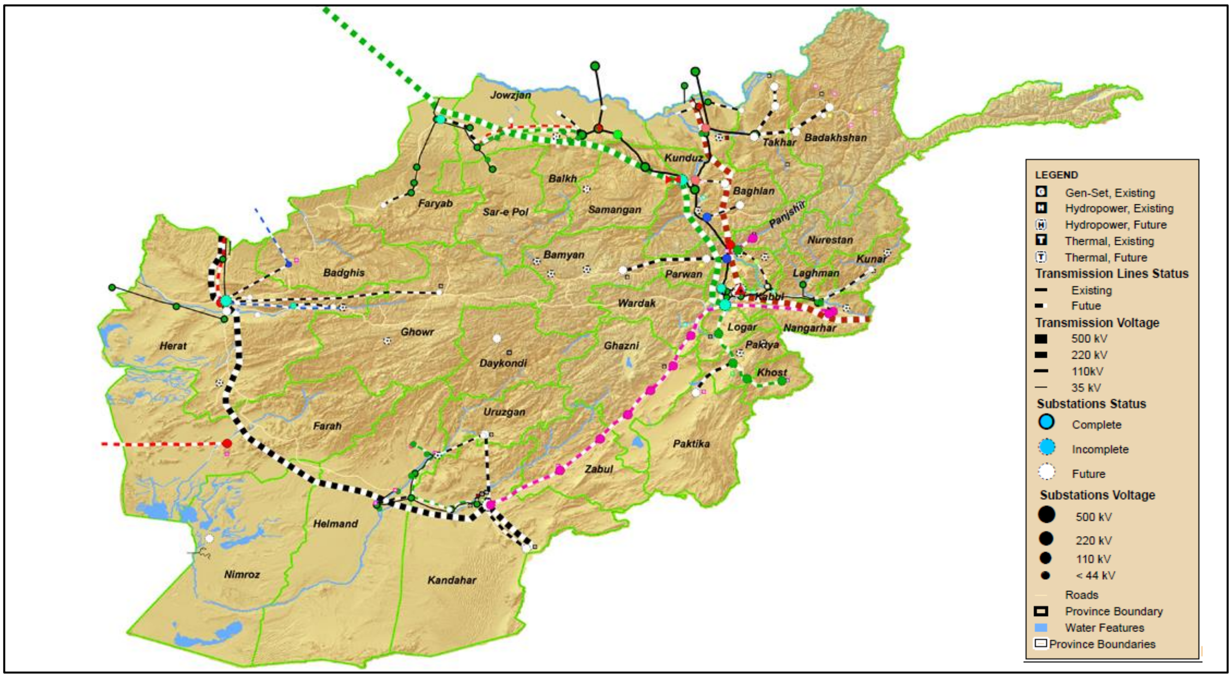


Figure 60 Afghanistan Energy Map - Power Plants and Imports

Source: Afghan Energy Information Center (AEIC), Ministry of Energy and Water , http://aeic.af/en/ppi

Currently the Afghan Power Infrastructure is categorized into 4 general networks:

(1) North East Power System (NEPS), consisting of a grid linking 17 load centers (Kabul, Mazar-i-Shariff, Jalalabad, etc.) with Uzbekistan and Tajikistan Power grid (220 kV, 110 kV);
(2) South East Power System (SEPS), consisting of Kandahar, linking Kajaki (110 kV);
(3) Herat system linking the Herat Zone with Iran (110 kV);
(4) Turkmenistan system linking the Herat, Aqina, Andkhoi East/West, Shirin Tagab, Mimana, Khoja Doko, Sarepul, Shibirghan, Mazar (110 kV).

Table 55 Installed and operating capacity of diesel, thermal and hydro power plants.

	Installed Capacity (MW)	Share	Operating Capacity (MW)
Diesel Power plant	107.9	8%	42.8
Thermal Power plant	851.4	66%	197.0
Hydro Power plant	324.3	25%	196.3
Total	1 283.5	100%	436.1

Source: Afghan Energy Information Center (AEIC), Ministry of Energy and Water , http://aeic.af/en/ppi

Afghanistan can partly provide itself with self-produced energy. The electricity mix is dominated by electricity imports (80 %) that are complemented by domestic hydropower (see Figure 61 and Table 56). Afghanistan has limited indigenous sources of electricity, with only approximately 1 2834 MW of installed capacity, which is a mix of hydro power (25%), thermal power (66%) and diesel power (8%) in 2014 (see Table 55). However, the operating capacity is about 436 MW.

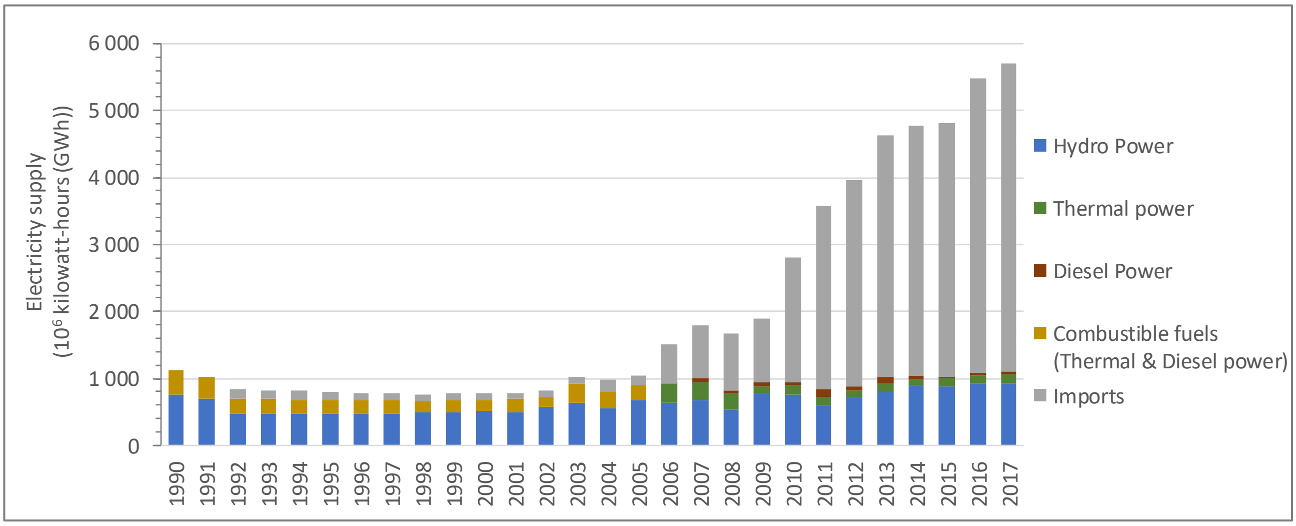


Figure 61 Electricity supply – National Production and Imports: 1990 – 2017

In 2008, over half of the energy supply came from imports. This is due to the deterioration in energy infrastructure rather than an increase in consumption.[46] In 2018 about 81% of the energy supply came from imports.

Qargha, Kabul ©Mohammad Monib Noori

[46] Energy Sector Strategy 1387-1391 (2008-2013); available (15 March 2019) on http://mew.gov.af/Content/files/Energy_Sector_Strategy-English.pdf

Table 56 National electricity production (hydro, thermal and diesel power) and imports of electricity: 1990 – 2017

	Total	Hydro Power	Combustible fuels			Imports	Hydro Power	Combustible fuels			Imports	Source
				Thermal power	Diesel power				Thermal power	Diesel power		
	10^6 kilowatt-hours (GWh)											
1990	1 128	764	364			0	67.7%	32.3%			0.0%	UN Statistics Division (UNSD) - Energy Statistics Section
1991	1 015	690	325			0	68.0%	32.0%			0.0%	
1992	834	478	225			131	57.3%	27.0%			15.7%	
1993	825	475	220			130	57.6%	26.7%			15.8%	
1994	815	472	215			128	57.9%	26.4%			15.7%	
1995	795	466	209			120	58.6%	26.3%			15.1%	
1996	785	475	200			110	60.5%	25.5%			14.0%	
1997	770	485	185			100	63.0%	24.0%			13.0%	
1998	760	495	170			95	65.1%	22.4%			12.5%	
1999	780	505	180			95	64.7%	23.1%			12.2%	
2000	783	516	172			95	65.9%	22.0%			12.1%	
2001	786	503	188			95	64.0%	23.9%			12.1%	
2002	822	571	151			100	69.4%	18.4%			12.2%	
2003	1 021	647	274			100	63.4%	26.8%			9.8%	
2004	987	565	232			190	57.2%	23.5%			19.3%	
2005	1 043	671	235			137	64.3%	22.5%			13.1%	
2006	1 511	646	*324*	267	4	594	42.8%		17.7%	0.2%	39.3%	National Statistics and Information Authority (NSIA) Diesel: Da Afghanistan Breshna Sherkat
2007	1 792	684	*286*	267	57	785	38.2%		14.9%	3.2%	43.8%	
2008	1 662	542	*162*	247	39	835	32.6%		14.8%	2.3%	50.2%	
2009	1 894	776	*185*	114	48	957	40.9%		6.0%	2.5%	50.5%	
2010	2 803	751	*251*	141	44	1 867	26.8%		5.0%	1.6%	66.6%	
2011	3 579	595	*174*	124	128	2 732	16.6%		3.5%	3.6%	76.3%	
2012	3 954	709	*218*	107	67	3 071	17.9%		2.7%	1.7%	77.7%	
2013	4 638	804	*156*	109	110	3 615	17.3%		2.3%	2.4%	78.0%	
2014	4 762	895	*141*	81	75	3 711	18.8%		1.7%	1.6%	77.9%	
2015	4 810	890	*152*	111	30	3 779	18.5%		2.3%	0.6%	78.6%	
2016	5 479	927	*171*	118	34	4 400	16.9%		2.2%	0.6%	80.3%	
2017	5 712	930	*324*	143	28	4 611	16.3%		2.5%	0.5%	80.7%	
Trend												
1990-2017	*406%*	*22%*	*-53%*			-						
2005-2017	*448%*	*39%*	*-27%*			*3266%*						
2016-2017	*4%*	*0%*	*12%*	*21%*	*-17%*	*5%*						

3.2.5 Energy Industries (IPCC category 1.A.1)

Energy industries are defined as consisting of economic units whose principal activity is primary energy production, transformation of energy or distribution[47]. This section describes GHG emissions resulting from fuel combustion activities (fuel extraction or energy-producing industries) in energy industries, which, originate from

- public electricity and heat production plants (IPCC category 1.A.1.a);
- petroleum refining (IPCC category 1.A.1.b);
- manufacturing of solid fuels (IPCC category 1.A.1.c).

3.2.5.1 Main Activity Electricity and Heat Production (IPCC category 1.A.1.a)

3.2.5.1.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.1.a.i	✓	NO	IE	NO	NO	NO	✓	NO	IE	NO	NO	NO	✓	NO	IE	NO	NO	NO
1.A.1.a.ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.a.iii	NE	NO	IE	NO	NO	NO	NE	NO	IE	NO	NO	NO	NE	NO	IE	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE	1.A.1.a.i gaseous	Natural gas is used in one power plant which is mainly serving the Northern Fertilizer Power Plant (NFPP). Therefore, these activity data and emissions are included in IPCC sub-category 1.A.2.c *Chemicals*.
IE	1.A.1.a.ii (all fuels)	Combined Heat and Power Generation (CHP) could not be identified in Afghanistan.
NE	1.A.1.a.iii (all fuels)	The amount of fuel consumption is not available.

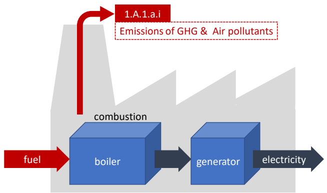
This section describes GHG emissions resulting from fuel combustion activities in energy industries which, originate from public electricity and heat production plants. Two types of producers can be distinguished: Main activity producer and auto-producer. According to 2006 IPCC Guidelines main activity producers are defined as those undertakings whose primary activity is to supply the public.

Type of producer	Electricity plant	Heat plant	Remark
Main activity producer	• units that produce electricity or heat as their principal activity;		They may be in public or private ownership. Emissions from own on-site use of fuel are also included.
Auto-producer	• units that produce electricity but for which the production is not their principal activity;	• units that produce heat for sale but for which the production is not their principal activity;	

[47] For more information see https://unstats.un.org/unsd/energy/ires/IRES-web.pdf

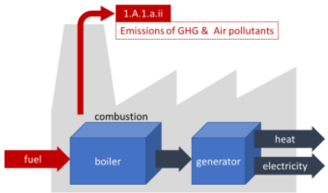
The following sub-categories are defined in the 2006 IPCC Guidelines:

1.A.1.a.i Electricity Generation



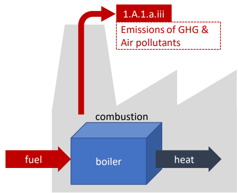
Comprises emissions from all fuel use for electricity generation from main activity producers except those from combined heat and power plants.

1.A.1.a.ii Combined Heat and Power Generation (CHP)



Emissions from production of both heat and electrical power from main activity producers for sale to the public, at a single CHP facility.

1.A.1.a.iii Heat Plants



Production of heat from main activity producers for sale by pipe network.

An overview of the GHG emission from fuel combustion in IPCC sub-category 1.A.1.a *Main Activity Electricity and Heat Production* is provided in the following figure and table. The share in total GHG emissions from sector 1.A.1.a is 0.2% for the year 1990, 0.6% for the year 2005, and 0.1% for the year 2017.

In the period 1990 to 2017 GHG emissions from sub-category 1.A.1.a decreased by -6.5% from 45.07 Gg CO_2 eq in 1990 to 42.155 Gg CO_2 eq in 2017. Emissions from sub-category 1.A.1.a increased by 184% in the period 1990 - 2005. In the period 2005 to 2017 GHG emissions from sub-category 1.A.1.a decreased by 67% from 127.959 Gg CO_2 equivalents in 2005 to 42.155 Gg CO_2 equivalents in 2017. In the period 2016 to 2017 GHG emissions from the IPCC sub-category 1.A.1.a *Main Activity Electricity and Heat Production* increased by 31.6%. Energy in Afghanistan is primarily provided by hydropower and imports. The fluctuation of the GHG emissions are mainly due to increased electricity consumption for heating coupled with non-availability of hydropower

- in winter;
- during drought and seasonal conditions, 2002-2003 and 2004, 2008, 2013;
- increased demand in rural areas by hybrid stand-alone power systems.

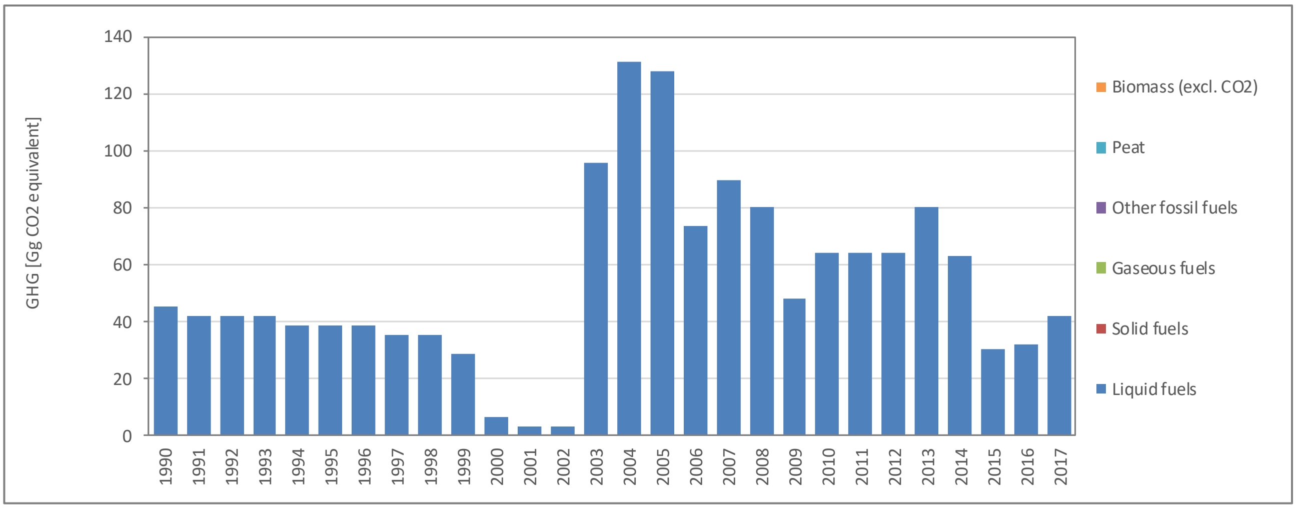


Figure 62 Emissions from IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

Table 57 Emissions from IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
Years	**Gg** $_{CO_2\ equivalent}$	**Gg** $_{CO_2\ equivalent}$	**Gg** $_{CO_2\ equivalent}$	**Gg** $_{CO_2\ equivalent}$	**Gg** $_{CO_2\ equivalent}$
1990	45.074	44.925	0.038	0.111	NO
1991	41.798	41.660	0.035	0.104	NO
1992	41.719	41.580	0.035	0.104	NO
1993	41.719	41.580	0.035	0.104	NO
1994	38.522	38.394	0.032	0.096	NO
1995	38.522	38.394	0.032	0.096	NO
1996	38.522	38.394	0.032	0.096	NO
1997	35.325	35.208	0.030	0.088	NO
1998	35.325	35.208	0.030	0.088	NO
1999	28.852	28.756	0.024	0.072	NO
2000	6.473	6.452	0.005	0.016	NO
2001	3.276	3.266	0.003	0.008	NO
2002	3.276	3.266	0.003	0.008	NO
2003	95.989	95.668	0.081	0.240	NO
2004	131.077	130.638	0.111	0.328	NO
2005	127.959	127.531	0.108	0.320	NO
2006	73.610	73.364	0.062	0.184	NO
2007	89.733	89.433	0.076	0.224	NO
2008	80.142	79.874	0.068	0.200	NO
2009	48.172	48.011	0.041	0.120	NO
2010	64.157	63.943	0.054	0.160	NO
2011	64.157	63.943	0.054	0.160	NO
2012	64.157	63.943	0.054	0.160	NO
2013	80.142	79.874	0.068	0.200	NO
2014	62.942	62.732	0.053	0.157	NO
2015	30.320	30.219	0.025	0.075	NO
2016	32.030	31.923	0.027	0.080	NO
2017	42.155	42.017	0.035	0.103	NO
Trend					
1990 - 2017	*-6%*	*-6%*	*-7%*	*-7%*	-
2005 - 2017	*-67%*	*-67%*	*-68%*	*-68%*	-
2016 - 2017	*32%*	*32%*	*30%*	*30%*	-

3.2.5.1.2 Methodological issues

3.2.5.1.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[48] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

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

Where:

Emissions $_{GHG,\,fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\,fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{\mathbf{GHG,\,fuel}}}$$

Air pollutants emissions

For estimating the air pollutants emissions (NO_x, CO, NMVOC, SO_2) the Tier 1 approach[49] of the EMEP/EEA air pollutant emission inventory guidebook 2016 has been applied:

Equation 2.1: GHG emissions from stationary combustion

$$\boldsymbol{Emissions_{pollutant} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{pollutant,\,fuel}}$$

Where:

Emissions $_{pollutant}$	= emissions of a given pollutant by type of fuel (kg pollutant)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{pollutant,\,fuel}$	= default emission factor of a given pollutant by type of fuel (g $_{pollutant}$/GJ).
Pollutant	= NOx, CO, NMVOC, SO_2

3.2.5.1.2.2 Choice of activity data

The following fuels are used for electricity production:

Liquid fuels: Gas/Diesel Oil

- L62 Diesel[50]
- Diesel According to EN 590 or ASTM D-975 Test Method

Residual fuel

- Diesel & Marine Diesel Oil (MDO)

Gaseous fuels: Natural Gas

[48] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

[49] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, 1.A.1 Energy industries, sub-chapter 3.4.2 Tier 1 default approach.

[50] Also known as Gasoil or D2 which is the second distillate obtained from crude oil. There are varying contents of sulphur in Gasoil and D2 products that will affect when the fuel is best to use (seasons) and the cost thereof. Reformers and additives are not required to make use of this fuel. The version of D2 that has lower sulphur content is GOST 305-82 and it is the presentation of this to the market that has helped in a major reduction in pollution in many cities.

Nearly all of thermal generation comes from reciprocating engines (four stroke diesel Engines turbo charger) with the exception of the Kabul NE power plant, which consists of two diesel - fired gas turbines (see Table 58).

Natural gas is used in one power plant which is mainly serving the Northern Fertilizer Power Plant (NFPP) in Mazar-e-Sharif. The Northern Fertilizer Power Plant (NFPP) is an autoproducer which is also provides electricity to the public. As the principal activity is fertilizer production, the activity data and emissions are included in IPCC sub-category 1.A.2.c *Chemicals* and IPCC sub-category *2.B.1 Ammonia Production.*

Table 58 Thermal and Diesel Power plants, capacity and output (2015)

Province	Name	Year Built	Unit	Unit configuration	Capacity Installed (MW)	Capacity Operating (MW)	Type of Engine	Type of fuel
Kabul	Tarakhail	2009	18	18x6.02	108.36	105	Four stroke marine diesel engines turbo charger	Diesel & MDO
Kabul	North-West	2007	2	2x25	50	40	AEG / BBC Gas turbine	L62 Diesel
Kabul	North-West (Unit 3&4)	1975	2	1x23.2 &1x21.8	45	40		Diesel
Kandahar	Shorandam Industerial Park	2011	8	8x2	16	4.5	Four stroke diesel engines turbo charger	Diesel According to EN 590 or ASTM D-975 Test Method
Kandahar	Bagh-e Pul	2014	8	8x2	16	8		
Kandahar	Spin Boldak		2	2x0.440	0.88	0.22		
Zabul	Qalat	2006	2	1x0.850 & 1x0.880	1.73	1		
Urozgan	Tirin Kot	2003	4	1x1.440 & 1x0.48 & 2x0.440	2.8	1.44		
Helmand	Musa Qala	2008	1	1x0.88	0.88	0		
Helmand	Lashkar Gah	2003	2	2x1.5	3	2.4		
Khost	Khost	2003	9	1x0.080 & 1x0.120 & 2x0.320 & 1x0.800 & 1x0.510 & 2x0.400	3.46	1.04		
Paktia	Gardez	2008	6	1x0.440 & 1x0.520 & 1x0.880 & 1x0.132 & 1x0.120 & 1x0.200	2.292	0.64		
Ghazni	Ghazni	2008	12	5x0.440 & 1x0.400 & 2x0.600 & 1x0.750 & 3x1.5	9.02	1.72		
Logar	Pul-e-Alam	2007	3	1x0.480 & 1x0.400 & 1x1.520	2.4	0.88		
Badakhshan	Faizabad	2007	3	1x0.132 & 1x0.44 & 1x0.904	1.476	0.132		
Farah	Farah	2003	5	2x0.440 & 1x0.400 & 1x0.360 & 1x0.800	2.44	2		
Ghor	Feroz koh	2003	2	1x0.480 & 1x0.200	0.68	0.6		
Badghis	Badghis	2008	2	1x0.400 & 1x0.440	0.84	0.5		
Herat	Shindand	no in	2	1x0.500 & 1x1.030	1.53	1.03		
Bamyan	Bamyan	2008	2	1x0.132 & 1x 0.480	0.612	0.48		
Daikondi	Daikondi	no in	1	1x0.132	0.132	0.132		
Kunar	Asad Abad	2009	2	1x0.132 & 1x0.904	1.036	0		
Balkh	Mazar-e Sharif Fertilizer & Power Factory	1971	4	4x12	48	12	gas-to-power plant gas turbine	Natural Gas
Jawzjan	Sheberghan Gas Turbine	no in	4	4x50	200	N/A	x	Natural Gas

Province	Name	Year Built	Unit	Unit configuration	Capacity		Type of Engine	Type of fuel
					Installed	Operating		
				(MW)				
Remark: *no in*: no information available								

Source: Afghan Energy Information Center (AEIC), Ministry of Energy and Water (2019)[51]

Fuel consumption used for estimating the GHG and non-GHG emissions are taken for the years

- 2014 - 2017 from **plant specific data** prepared by Da Afghanistan Breshna Sherkat (DABS);
- 2006 - 2013 from the national energy statistics prepared by Ministry of Energy & Water (MEW) and National Statistics and Information Authority (NSIA);
- 1990 – 2005 from the UN Statistics Division (UNSD) - Energy Statistics Section. The data of the years 2005, 2004 and 1992 are official data, the data of the other years are estimated by UNSD.

The total fuel consumption decreased by 7% in the period 1990 – 2017. From 2005 to 2017 the total fuel consumption decreased by 68%. From 2016 to 2017 the total fuel consumption increased by 30% due to increasing demand of electricity. The fluctuation of the fuel consumption are mainly due to increased electricity consumption for heating coupled with non-availability of hydropower in winter and during droughts. The annual fluctuations in fuel consumption in this sector is also due to the Afghan Civil War (1989–92, 1996–2001) and War in Afghanistan (2001–present).

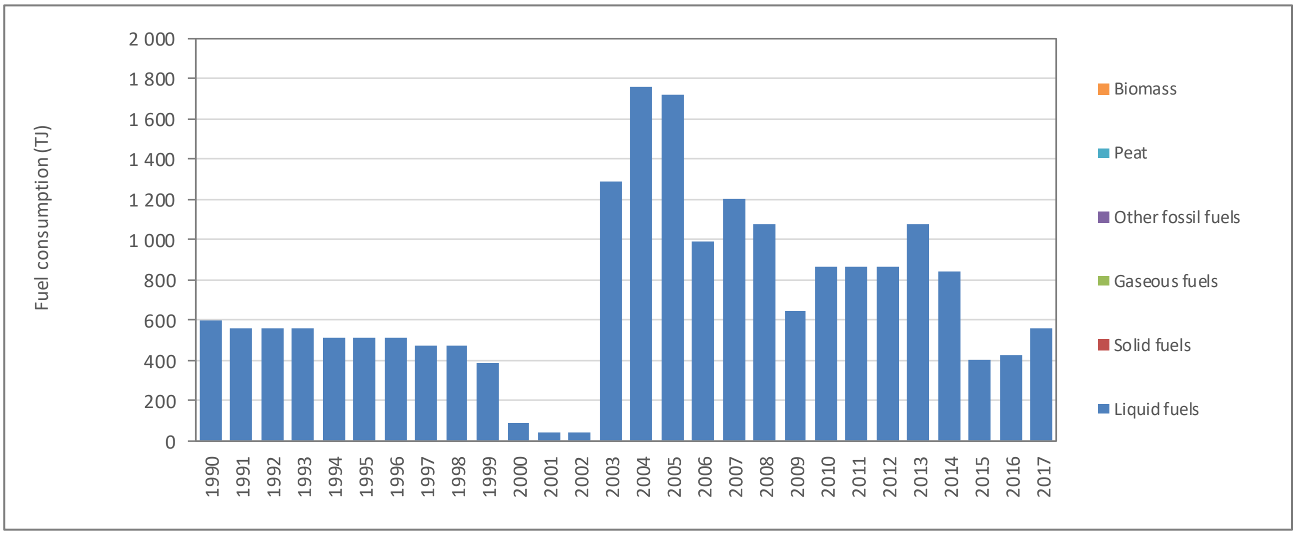


Figure 63 Activity data for IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

Table 59 Activity data for IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production and Public gross electricity production - Electricity plants

Activity data 1.A.1.a.i	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	599	599	NO	IE	NO	NO	NO
1991	557	557	NO	IE	NO	NO	NO
1992	557	557	NO	IE	NO	NO	NO

[51] Available (28 March 2019) on http://aeic.af/en/ppi

Activity data 1.A.1.a.i	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1993	557	557	NO	IE	NO	NO	NO
1994	514	514	NO	IE	NO	NO	NO
1995	514	514	NO	IE	NO	NO	NO
1996	514	514	NO	IE	NO	NO	NO
1997	471	471	NO	IE	NO	NO	NO
1998	471	471	NO	IE	NO	NO	NO
1999	386	386	NO	IE	NO	NO	NO
2000	85	85	NO	IE	NO	NO	NO
2001	42	42	NO	IE	NO	NO	NO
2002	42	42	NO	IE	NO	NO	NO
2003	1 289	1 289	NO	IE	NO	NO	NO
2004	1 763	1 763	NO	IE	NO	NO	NO
2005	1 719	1 719	NO	IE	NO	NO	NO
2006	988	988	NO	IE	NO	NO	NO
2007	1 205	1 205	NO	IE	NO	NO	NO
2008	1 076	1 076	NO	IE	NO	NO	NO
2009	646	646	NO	IE	NO	NO	NO
2010	861	861	NO	IE	NO	NO	NO
2011	861	861	NO	IE	NO	NO	NO
2012	861	861	NO	IE	NO	NO	NO
2013	1 076	1 076	NO	IE	NO	NO	NO
2014	843	843	NO	IE	NO	NO	NO
2015	404	404	NO	IE	NO	NO	NO
2016	428	428	NO	IE	NO	NO	NO
2017	556	556	NO	IE	NO	NO	NO
Trend							
1990 - 2017	*-7%*	*-7%*	-	-	-	-	-
2005 - 2017	*-68%*	*-68%*	-	-	-	-	-
1990 - 2017	*30%*	*30%*	-	-	-	-	-

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic metres. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.1.a *Main Activity Electricity and Heat Production*.

Table 60 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Gas/Diesel Oil	liquid	43.0	D	**2006 IPCC Guidelines, Vol. 2, Chap.**

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Gas/diesel oil - L62 Diesel	liquid	43.0	D	**1, Table 1.2** Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
Residual Fuel Oil / Total fuel oil • Diesel & MDO	liquid	42.19	D	**Table C.2**, 3. Market Survey of Marine Distillates with 0.2% Sulphur Content[52]
Note: D Default CS Country specific PS Plant specific				

3.2.5.1.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 61 GHG Emission factor TIER 1 for IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	**2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)**
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.2** Default emission factors for stationary combustion in the energy industries (page 2.16)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	
Note: D Default CS Country specific PS Plant specific IEF Implied emission factor								

Default emission factors for air pollutant were taken from the EMEP/EEA air pollutant emission inventory Guidebook 2016 and are presented in the following table.

Table 62 Non-GHG Emission factor for IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

Fuel	Fuel type	NOx (g/GJ)		CO (g/GJ)		NMVOC (g/GJ)		SO_2 (g/GJ)		Source
		EF	type	EF	type	EF	type	EF	type	**EMEP/EEA Guidebook 2016, Part B, Vol 1 - 1A, chap. 1.A.1**
Gas/Diesel Oil	liquid	65	D	16.2	D	0.8	D	46.5	D	**Table 3-5** Tier 1 emission factors for source category 1.A.1.a using heavy fuel oil (page. 16)
Residual Fuel Oil / Total fuel oil	liquid	142	D	15.1	D	2.3	D	495.0	D	**Table 3-6** Tier 1 emission factors for source category 1.A.1.a using gas oil (page. 20)
Note: D Default CS Country specific PS Plant specific IEF Implied emission factor										

3.2.5.1.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.1.a *Main Activity Electricity and Heat Production* are presented in the following table.

[52] Available (12. January 2019) on http://ec.europa.eu/environment/air/pdf/chapter3_end_ship_emissions.pdf

Table 63 Uncertainty for IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production.

Uncertainty	Liquid fuels			Reference
	CO_2	CH_4	N_2O	2006 IPCC GL, Vol. 2, Chap. 2 (2.4.2)
Activity data (AD)	2%	2%	2%	Table 2.15
Emission factor (EF)	2%			Table 2.13
		100%		Table 2.12
			20%	Table 2.14
Combined Uncertainty (U)	2%	100%	20%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.2.5.1.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps;

⇒ indicators and analysis – produced, imported and consumed electricity.

3.2.5.1.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category *1.A.1.a Main Activity Electricity and Heat Production*.

Table 64 Recalculations done since SNC in IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.1.a	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.1.a	Reallocation of fuel consumption (natural gas, solid fuels) to relevant subcategories – 1.A.2	AD	Transparency Comparability
1.A.1.a	use of default NCV of 2006 IPCC Guidelines	AD	Comparability

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.1.a	use of default EF of 2006 IPCC Guidelines	EF	Comparability
1.A.1.a	application of 2006 IPCC Guidelines	method	Comparability

3.2.5.1.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 65 Planned improvements for IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.1.a.iii	Survey for use of fuels in Heat Plants: The amount of fuel consumption is not known yet.	AD	Completeness	high
1.A.1.a.i	Survey for use of fuels in Electricity Plants: Plant specific data for longer time series (currently only 2014 - 2017)	AD	Completeness	medium
1.A.1.a	Cross-check of national and international data sources and feedback to UNSD	AD	Consistency Transparency	medium
1.A.1.a	Country specific Net Caloric Value (NCV) for imported fuels: diesel and residual fuel ⇒ conversion from mass unit to energy unit (unit EF is kg /TJ)	AD EF	Accuracy Transparency	medium
1.A.1.a	Carbon content (%) of gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	medium
1.A.1.a	Sulphur content in used fuel for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{SO2}$** [g/GJ] = (S [%] • 20000) / (NCV [GJ/t])	EF non-GHG	Accuracy Transparency	medium
1.A.1.a	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF non-GHG	Accuracy Transparency	medium
1.A.1.a	Data obtained from measurements made on the emission of air polluters (NON-GHG inventory) • Determination of the o temperature in waste gases [°C]; o static pressure and the dynamic pressure [kPa]; o flow rate [m/s]; o volume flow rate [m^3/h and Nm^3/h]; o concentration of CO, SO_2, NOx in the exhaust gases [mg/Nm^3]; and • Gravimetric extraction of solid particles (TSP) from gases and determination by applying a gravimetric method (mg/Nm^3).	EF non-GHG	Accuracy Transparency	medium

3.2.5.2 Petroleum Refining (IPCC category 1.A.1.b)

3.2.5.2.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.1.b	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment

This section describes GHG emissions resulting from fuel combustion activities in refineries:

- supporting the refining of petroleum products - heating of crude and petroleum products without contact between flame and products -, and
- on-site combustion for the generation of electrical and thermal energy for own use.

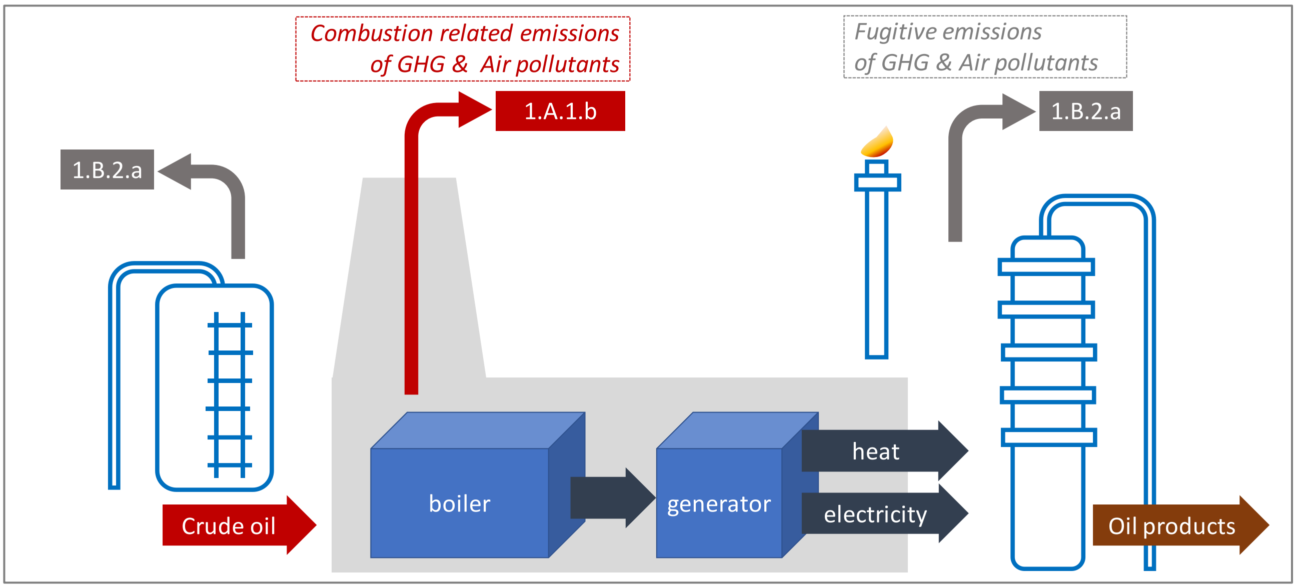


Figure 64 Schematic scheme of a refinery

Electrical and thermal energy is typically generated by combined heat and power (CHP) or cogeneration facilities at the refinery. Thermal energy can be provided directly (process furnaces on the production unit) or via steam produced within the production unit or from a utility's facility. The evaporative emissions occurring at the refinery through thermal cracking and catalyst regenerator units as well as venting, flaring and fugitive emissions are reported separately under IPCC sub-category 1.B.2.a.

In a petroleum refinery, crude oil and natural gas liquids (NGL) are converted to a broad range of products. In the following table the oil products which are extracted, refined and produced in Afghanistan are presented. Oil is produced in limited quantities primarily from the Angot oil field, located in Sar-i-Pol province. Few small petroleum refineries were established in Afghanistan during the past few years.

Table 66 Overview on Primary versus Secondary Oil, and indication of products produced in Afghanistan

	Product name	
Primary Oil Products	Crude oil	
	Natural gas liquids (NGL)	
	Other hydrocarbons	
Secondary Products Inputs to Refinery	Additives/blending components	
	Refinery feedstocks	
Secondary Oil Products	Refinery gas	Transport diesel
	Ethane	Heating and other gasoil (Mazut)
	Liquefied petroleum gases (LPG)	Residual fuel: low-sulphur / high-sulphur content
	Naphtha	White spirit + SBP
	Aviation gasoline	Lubricants
	Gasoline type jet fuel	Bitumen
	Unleaded / Leaded gasoline	Paraffin waxes
	Kerosene type jet fuel	Petroleum coke
	Other kerosene	Other products
In GREEN: Extraction, refining and production in Afghanistan		

An overview of the GHG emission from fuel combustion in IPCC sub-category 1.A.1.b *Petroleum Refining* is provided in the following figure and table. The share in total GHG emissions from sector 1.A.1.b is less than 0.01% for the year 1990, 0.01% for the years 2005 and 2017.

In the period 1990 to 2017 GHG emissions from sub-category 1.A.1.b increased by 316.2% from 0.82 Gg CO_2 eq in 1990 to 3.41 Gg CO_2 eq in 2017. In the period 2005 to 2017 GHG emissions from sub-category 1.A.1.b increased by 177.5%. The significant increases of the GHG emissions are mainly due to the construction of oil refineries.

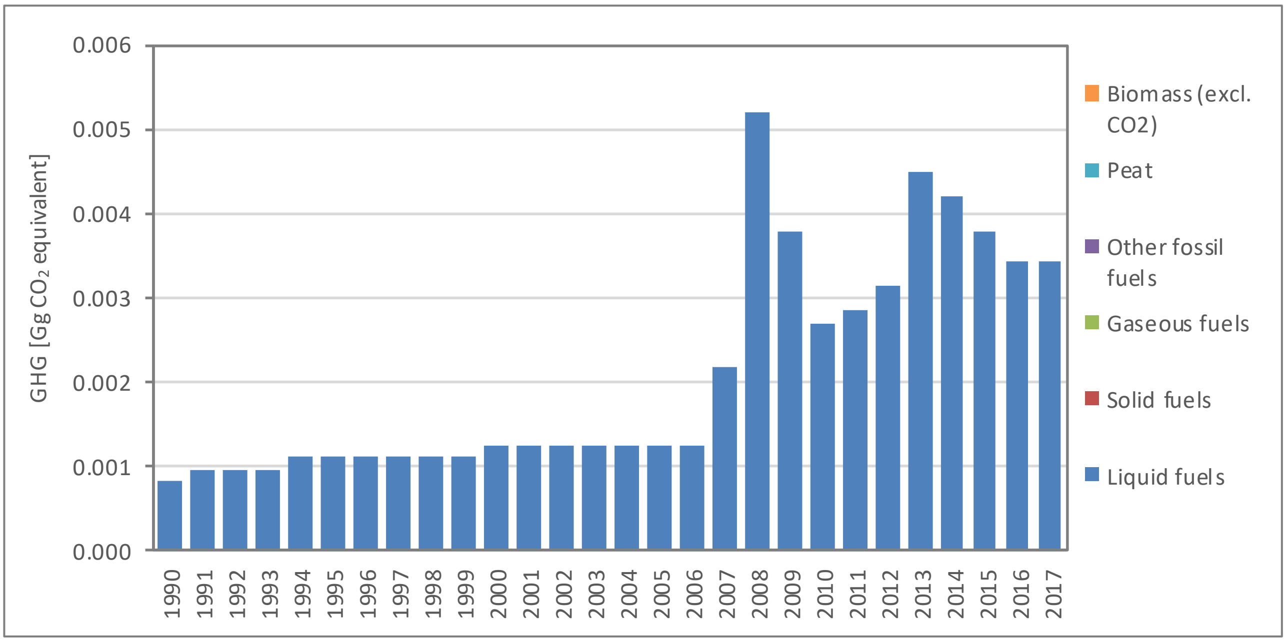


Figure 65 Emissions from IPCC sub-category 1.A.1.b Petroleum Refining

Table 67 GHG Emissions from IPCC sub-category 1.A.1.b Petroleum Refining: 1990 – 2017.

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
Years	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	0.000822	0.000819	0.000001	0.000002	NO
1991	0.000959	0.000955	0.000001	0.000003	NO
1992	0.000959	0.000955	0.000001	0.000003	NO
1993	0.000959	0.000955	0.000001	0.000003	NO
1994	0.001096	0.001091	0.000001	0.000003	NO
1995	0.001096	0.001091	0.000001	0.000003	NO
1996	0.001096	0.001091	0.000001	0.000003	NO
1997	0.001096	0.001091	0.000001	0.000003	NO
1998	0.001096	0.001091	0.000001	0.000003	NO
1999	0.001096	0.001091	0.000001	0.000003	NO
2000	0.001233	0.001228	0.000001	0.000004	NO
2001	0.001233	0.001228	0.000001	0.000004	NO
2002	0.001233	0.001228	0.000001	0.000004	NO
2003	0.001233	0.001228	0.000001	0.000004	NO
2004	0.001233	0.001228	0.000001	0.000004	NO
2005	0.001233	0.001228	0.000001	0.000004	NO
2006	0.001233	0.001228	0.000001	0.000004	NO
2007	0.002166	0.002158	0.000002	0.000006	NO
2008	0.005206	0.005187	0.000005	0.000015	NO
2009	0.003782	0.003768	0.000004	0.000011	NO
2010	0.002686	0.002676	0.000003	0.000007	NO
2011	0.002851	0.002840	0.000003	0.000008	NO
2012	0.003152	0.003140	0.000003	0.000009	NO
2013	0.004497	0.004481	0.000004	0.000012	NO
2014	0.004210	0.004194	0.000004	0.000012	NO
2015	0.003781	0.003767	0.000004	0.000010	NO
2016	0.003421	0.003408	0.000003	0.000009	NO
2017	0.003421	0.003408	0.000003	0.000009	NO
Trend 1990 - 2017	*316%*	*316%*	*299%*	*299%*	-
Trend 2005 - 2017	*178%*	*178%*	*166%*	*166%*	-
Trend 2016 - 2017	*0%*	*0%*	*0%*	*0%*	-

3.2.5.2.2 Methodological issues

3.2.5.2.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[53] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

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

Where:

Emissions $_{GHG,\,fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\,fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ). For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}}$$

For estimating the air pollutants emissions (NOx, CO, NMVOC, SO_2) the Tier 1 approach[54] of the EMEP/EEA air pollutant emission inventory guidebook 2016 has been applied:

Air pollutants emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{pollutant} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{pollutant,\,fuel}}$$

Where:

Emissions $_{pollutant}$	= emissions of a given pollutant by type of fuel (kg pollutant)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{pollutant,\,fuel}$	= default emission factor of a given pollutant by type of fuel (g $_{pollutant}$/GJ).
Pollutant	= NOx, CO, NMVOC, SO_2

3.2.5.2.2.2 Choice of activity data

The following primary oil products are refined.

Liquid fuels: Crude oil
Natural Gas Liquids (NGL) (Petroleum, condensate)

As stated in the 2006 IPCC Guidelines[55], in many cases, the exact products and fuels used in refineries to produce the heat and steam needed to run the refinery processes are not easily derived from the energy statistics. The fuel combusted within petroleum refineries typically amounts to 6 to 10 percent of the total fuel input to the refinery, depending on the complexity and vintage of the technology. As no information about the technology and the process routes were available, it was assumed, that 10 % of the total fuel input to the refineries were combusted within petroleum refineries.

[53] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method.
[54] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, 1.A.1 Energy industries, sub-chapter 3.4.2 Tier 1 default approach.
[55] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.3.1 TIER 1 and TIER 2, page 2.31.

Fuel consumption used for estimating the GHG and non-GHG emissions are taken for the whole time series from

- Crude oil — British Geological Survey (BGS): World Mineral Production. Keyworth, Nottingham.[56]
- Natural Gas Liquids (NGL) (Petroleum, condensate) — U.S. Geological Survey (USGS): Mineral Industry of Afghanistan. Geological Survey Minerals Yearbook. [57]

The total fuel consumption increased by 299% in the period 1990 – 2017. From 2005 to 2017 the total fuel consumption increased by 178%. The increased of refining activities are due to increasing demand of oil products and increased number of refineries.

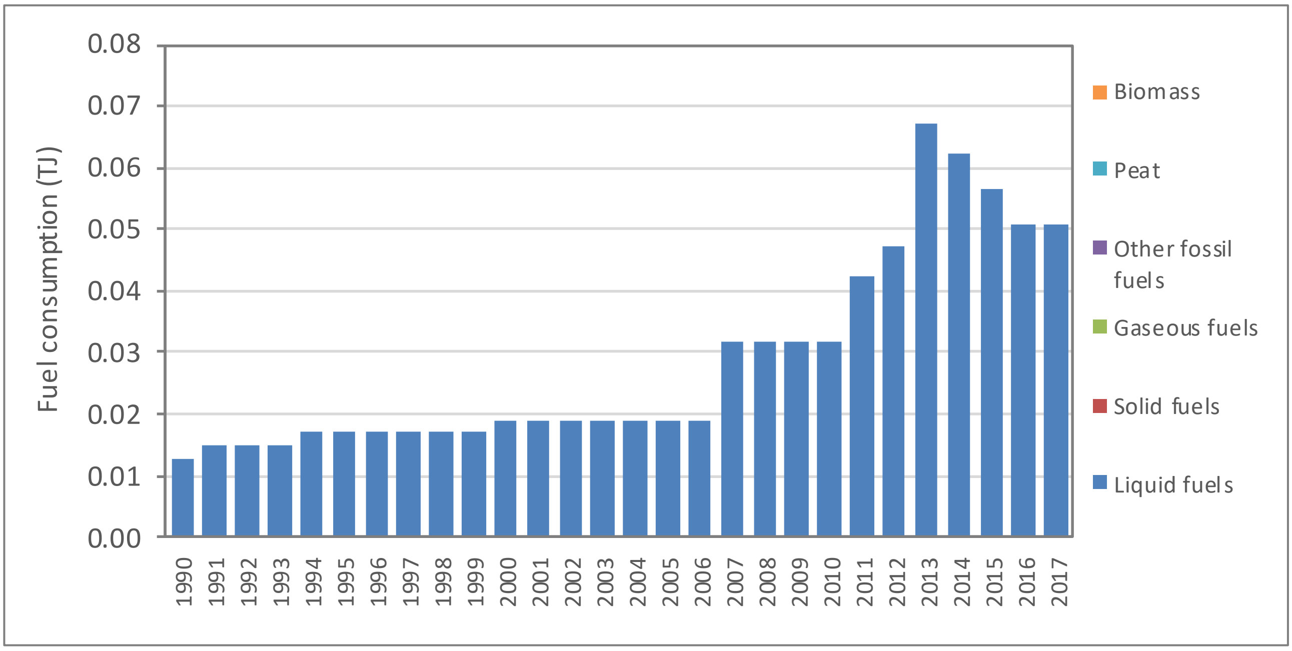


Figure 66 Activity data for IPCC sub-category 1.A.1.b Petroleum Refining: 1990 – 2017.

[56] Available (10 March 2019) on https://www.bgs.ac.uk/mineralsuk/statistics/worldArchive.html
[57] Available (10 March 2019) on https://www.usgs.gov/centers/nmic/asia-and-pacific#af

Table 68 Activity data for IPCC sub-category 1.A.1.b Petroleum Refining

Activity data 1.A.1.b	Total refinery input	Total fuel combustion	Natural Gas Liquids (NGL) (Petroleum, condensate)				Crude oil			
	Total	10%	Total refinery input		10%	Source	Total refinery input		10%	Source
	GJ	GJ	42-gallon barrels	GJ	GJ		tonnes	GJ	GJ	
1990	127.50	12.75	30 000	127.50	12.75	*e*	NO	NO	NO	
1991	148.75	14.88	35 000	148.75	14.88	*e*	NO	NO	NO	
1992	148.75	14.88	35 000	148.75	14.88	*e*	NO	NO	NO	
1993	148.75	14.88	35 000	148.75	14.88	*e*	NO	NO	NO	
1994	170.00	17.00	40 000	170.00	17.00	*e*	NO	NO	NO	
1995	170.00	17.00	40 000	170.00	17.00	*e*	NO	NO	NO	
1996	170.00	17.00	40 000	170.00	17.00	*e*	NO	NO	NO	
1997	170.00	17.00	40 000	170.00	17.00	*e*	NO	NO	NO	
1998	170.00	17.00	40 000	170.00	17.00	*e*	NO	NO	NO	
1999	170.00	17.00	40 000	170.00	17.00	*e*	NO	NO	NO	
2000	191.25	19.13	45 000	191.25	19.13	*e*	NO	NO	NO	
2001	191.25	19.13	45 000	191.25	19.13	*e*	NO	NO	NO	
2002	191.25	19.13	45 000	191.25	19.13	*e*	NO	NO	NO	
2003	191.25	19.13	45 000	191.25	19.13	*e*	NO	NO	NO	
2004	191.25	19.13	45 000	191.25	19.13	*e*	NO	NO	NO	
2005	191.25	19.13	45 000	191.25	19.13	*e*	NO	NO	NO	
2006	191.25	19.13	45 000	191.25	19.13	*e*	NO	NO	NO	
2007	318.15	31.82	45 000	191.25	19.13	*e*	3 000	126.90	12.69	*e*
2008	789.90	78.99	156 000	663.00	66.30	*r*	3 000	126.90	12.69	*e*
2009	568.90	56.89	104 000	442.00	44.20	*r*	3 000	126.90	12.69	*e*
2010	398.90	39.89	64 000	272.00	27.20	*r*	3 000	126.90	12.69	*e*
2011	424.40	42.44	70 000	297.50	29.75	*r*	3 000	126.90	12.69	*e*
2012	471.15	47.12	81 000	344.25	34.43	*r*	3 000	126.90	12.69	*e*
2013	670.90	67.09	113 000	480.25	48.03	*r*	4 507	190.65	19.06	*r*
2014	622.88	62.29	96 000	408.00	40.80	*r*	5 080	214.88	21.49	*r*
2015	564.51	56.45	96 000	408.00	40.80	*r*	3 700	156.51	15.65	*r*
2016	509.28	50.93	84 000	357.00	35.70	*r*	3 600	152.28	15.23	*e*
2017	509.28	50.93	84 000	357.00	35.70	*p*	3 600	152.28	15.23	*p*
Trend										
1990 - 2017	*299%*	*299%*	*180%*	*180%*	*180%*		-	-	-	
2005 - 2017	*166%*	*166%*	*87%*	*87%*	*87%*		-	-	-	
2016 - 2017	*0%*	*0%*	*0%*	*0%*	*0%*		*0%*	*0%*	*0%*	

Note
r reported data *e estimated data* *p preliminary data (2016 value)*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in 42-gallon barrels, tonnes or cubic metres. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. The (default) conversion factor 10.4 metric tonnes per barrel is taken from Table II of the UN Energy statistical yearbook 2016.[58] In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.1.b *Petroleum Refining* are presented.

Table 69 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.1.b Petroleum Refining

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	2006 IPCC Guidelines Vol. 2, Chap. 1 (sub-chap. 1.4.1.3)
Crude oil	liquid	42.30	D	Table 1.2 Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
Natural Gas Liquids (NGL) (Petroleum, condensate)	liquid	44.20	D	
Note: D Default CS Country specific PS Plant specific				

The output of 10 refineries for the year 2017 are presented in the following table.

Table 70 Output of all refineries for the year 2017

Parameter description	Unit	NCV	Fuel production	Source
Gasoline	tonnes		237 000	Ministry of Petroleum and Mining
	TJ		10 499	
NCV gasoline	TJ/Gg	44.3		Table 1.2, 2006 IPCC GL, Vol. 2, Chapt 1.
Addition	tonnes		23 700	Ministry of Petroleum and Mining
Diesel	tonnes		351 000	Ministry of Petroleum and Mining
	TJ		15 093	
NCV diesel	TJ/Gg	43.0		Table 1.2, 2006 IPCC GL, Vol. 2, Chapt 1.
Addition	tonnes		7 110	Ministry of Petroleum and Mining
Mazod	tonnes		462 900	Ministry of Petroleum and Mining
	TJ		19 118	
NCV mazut	TJ/Gg	41.3		

3.2.5.2.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

[58] Available (17 December 2018): on https://unstats.un.org/unsd/energy/yearbook/2016/09ii.pdf

Table 71 GHG Emission factor TIER 1 for IPCC sub-category 1.A.1.b Petroleum Refining

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Crude oil	liquid	73 300	D	3	D	0.6	D	Table 2.2 Default emission factors for stationary combustion in the energy industries (page 2.16)
Natural Gas Liquids (NGL) (Petroleum, condensate)	liquid	64 200	D	3	D	0.6	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

Default emission factors for air pollutant were taken from the EMEP/EEA air pollutant emission inventory Guidebook 2016 and are presented in the following table.

Table 72 Non-GHG Emission factor for IPCC sub-category 1.A.1.b Petroleum Refining

Fuel	Fuel type	NOx (g/GJ)		CO (g/GJ)		NMVOC (g/GJ)		SO_2 (g/GJ)		Source
		EF	type	EF	type	EF	type	EF	type	EMEP/EEA Guidebook 2016, Part B, Vol 1 - 1A, chap. 1.A.1 Table 4-1 Tier 1 fuel classifications
Crude oil	liquid	142	D	15.1	D	2.3	D	495	D	Table 3-5 Tier 1 emission factors for source category 1.A.1.a using heavy fuel oil (page. 16)
Natural Gas Liquids (NGL) (Petroleum, condensate)	liquid	89	D	39	D	2.6	D	0.281	D	Table 3-4 Tier 1 emission factors for source category 1.A.1.a using Gaseous fuels (page. 20)

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.5.2.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.1.b *Petroleum Refining* are presented in the following table.

Table 73 Uncertainty for IPCC sub-category 1.A.1.b Petroleum Refining.

Uncertainty	Liquid fuels			Reference
	CO_2	CH_4	N_2O	2006 IPCC GL, Vol. 2, Chap. 2
Activity data (AD)	10%	10%	10%	2.4.2 Activity data uncertainties
Emission factor (EF)	2%			Table 2.13
		100%		Table 2.12
			20%	Table 2.14
Combined Uncertainty (U)	10%	100%	22%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as data are taken from the same sources (BGS and USGS).

3.2.5.2.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.5.2.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category 1.A.1.b *Petroleum Refining*.

Table 74 Recalculations done since SNC in IPCC sub-category 1.A.1.b Petroleum Refining.

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.1.b	No recalculation as this source is estimated the first time		

3.2.5.2.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 75 Planned improvements for IPCC sub-category 1.A.1.b Petroleum Refining

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.1.b	Survey for use of fuel input, fuel consumption and fuel output in all refineries.	AD	Accuracy, Transparency	high
1.A.1.b	Cross-check of national (CSO/NSIA, MEW, MoPM) and international data sources (UNSD, BGS, USGS) and feedback to energy statistics	AD	Consistency Transparency	high
1.A.1.b	Country specific Net Caloric Value (NCV) for fuels of national production: Natural Gas Liquids (NGL) Petroleum, condensate ⇒ conversion from mass unit to energy unit (unit EF is kg /TJ)	AD EF	Accuracy Transparency	high

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.1.b	Carbon content (%) of Crude oil and Natural Gas Liquids (NGL) (Petroleum, condensate) etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox) / (NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	medium
1.A.1.b	Sulphur content in used fuel for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{SO2}$** [g/GJ] = (S [%] • 20000) / (NCV [GJ/t])	EF non-GHG	Accuracy Transparency	low/ medium
1.A.1.b	Information about the combustion technologies used: information about the type of combustion plant (steam generator, gas turbine, dry bottom boiler etc.)	EF non-GHG	Accuracy Transparency	medium
1.A.1.b	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF non-GHG	Accuracy Transparency	low/ medium
1.A.1.b	Data obtained from measurements made on the emission of air polluters (NON-GHG inventory) • Determination of the ○ temperature in waste gases [°C]; ○ static pressure and the dynamic pressure [kPa]; ○ flow rate [m/s]; ○ volume flow rate [m^3/h and Nm^3/h]; ○ concentration of CO, SO_2, NOx in the exhaust gases [mg/Nm^3]; and • Gravimetric extraction of solid particles (TSP) from gases and determination by applying a gravimetric method (mg/Nm^3).	EF non-GHG	Accuracy Transparency	low/ medium

GHG Inventory Training to the Members of the NSTs ©UNEP

3.2.5.3 Manufacture of Solid Fuels and Other Energy Industries (IPCC category 1.A.1.c)

The IPCC category 1.A.1.c *Manufacture of Solid Fuels and Other Energy Industries* is divided in two sub-categories:

1.A.1.c.i *Manufacture of Solid Fuels*

1.A.1.c.ii *Other Energy Industries*

3.2.5.3.1 Source category description

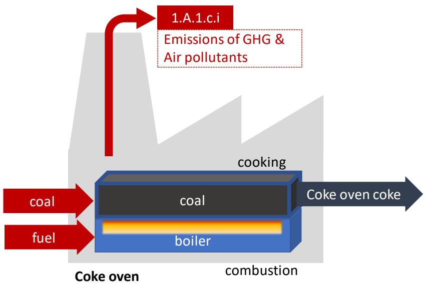
GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.1.c.i - coke oven coke	NO	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO
1.A.1.c.i - charcoal	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO	✓
1.A.1.c.ii	NO	IE	NO	NO	NO	IE	NO	IE	NO	NO	NO	IE	NO	IE	NO	NO	NO	IE
Key Category	-	-	-	-	-	-	-	LA 2017	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE 1.A.1.c.ii (all fuels) All emissions of fuels used in energy-producing industries as own (on-site) energy are included in 1.A.1.c.i *Manufacture of Solid Fuels*.

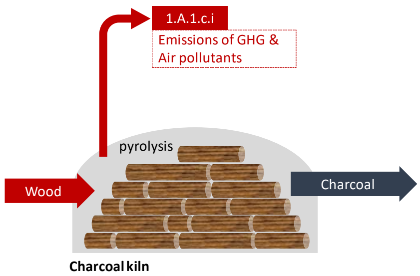
This section describes GHG emissions resulting from combustion activities from fuel use during the manufacture of secondary and tertiary products from solid fuels including production of charcoal. Emissions from own on-site fuel use should be included. Also includes combustion for the generation of electricity and heat for own use in these industries. In Afghanistan the following sub-categories are existing:

1.A.1.c.i - Coke oven coke production



Comprises emissions from arising from fuel combustion for the production of coke, brown coal briquettes etc.

1.A.1.c.i - Charcoal production



Comprises emissions from arising from pyrolysis in charcoal kilns.

1.A.1.c.i - Coke oven coke production

According to 2006 IPCC Guidelines Coke oven coke is the solid product obtained from the carbonization of coal, principally coking coal, at high temperature. It is low in moisture content and volatile matter. Also included are semi-coke, a solid product obtained from the carbonization of coal at a low temperature, lignite coke, semi-coke made from lignite/brown coal, coke breeze and foundry coke. Coke oven coke is also known as metallurgical coke.[59]

As described in the 'EMEP/EEA air pollutant emission inventory guidebook 2016' coke manufacture is a batch process with production occurring in a coke oven which is a battery of ovens. Coal is heated in a non-oxidizing atmosphere (pyrolysis). The volatile components are driven off to leave coke which is then pushed at high temperature from the oven into a rail car and taken to a quench tower to stop oxidation in air. Heating is provided by combustion of a portion of the evolved gases, following treatment to remove ammonia, hydrogen sulfide, tars and condensable organic material.

In Afghanistan the coke oven coke production facilities are not integrated with (primary) iron and steel production as only secondary steelmaking facilities are occurring. According to international statistics coke oven coke is completely exported.

1.A.1.c.i - Charcoal production

Charcoal combusted as energy covers the solid residue of the destructive distillation and pyrolysis of wood and other vegetal material.

Charcoal making is an old and honorable trade. Its origins are lost in prehistory and the traditional methods of making it have changed surprisingly little -from ancient times till now. The only new factors are that the simple methodologies have been rationalized and that science has verified the basic processes which take place during carbonization and spelled out the quantitative and qualitative laws which govern the process.[60]

An overview of the GHG emission from fuel combustion in IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels is provided in the following figure and table. The share in total GHG emissions from sector 1.A.1.c is 0.2% for the year 1990, 0.3% for the year 2005 and 0.8% for the year 2017. The CH_4 emission increased by 1160% in the period 1990 – 2017 and by 209% in the period 2005 – 2017. The increase of the CH_4 emission is mainly due to

- increasing production of charcoal due to rising demand of fuel by households;
- starting of coke oven coke production in 2008 with strongly rising production.

[59] Source: 2006 IPCC Guidelines, Volume 3: Energy, Chapter 4: Metal Industry Emissions - 4.2.2.1 Choice of method: metallurgical coke production

[60] FAO (1985): Industrial charcoal making. FAO FORESTRY PAPER 63. Rome. Available (14 April 2019) on: http://www.fao.org/3/X5555E/X5555E00.htm

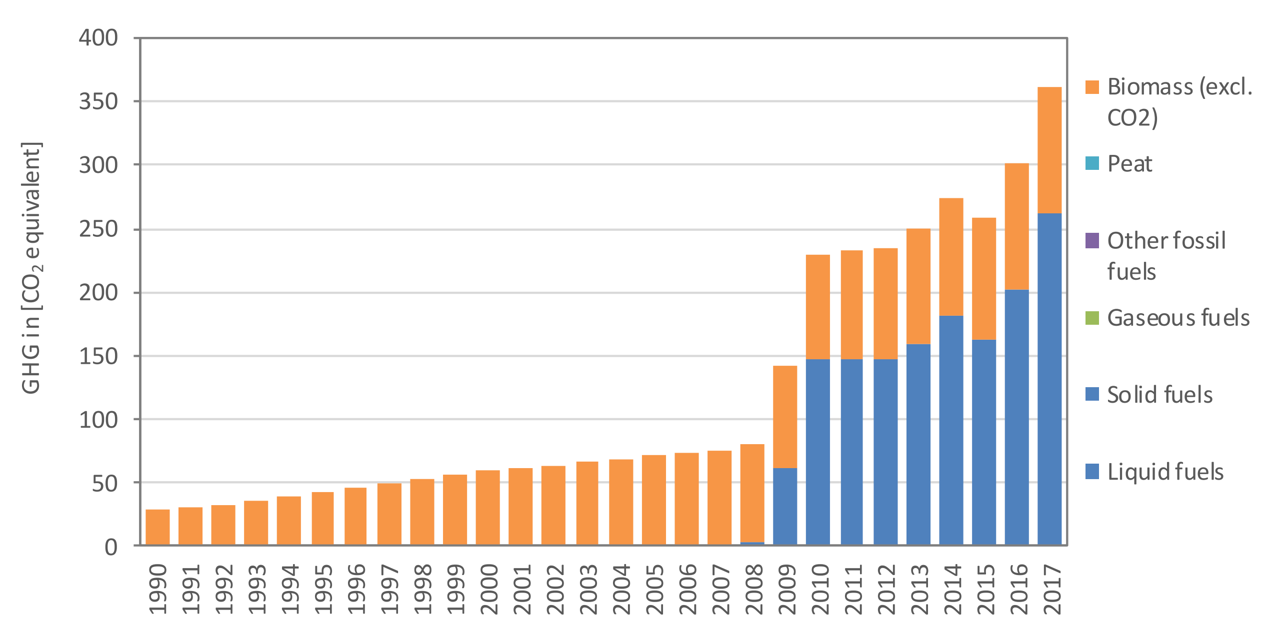


Figure 67 GHG Emissions from IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels

Table 76 Emissions from IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	28.76	NO	28.76	NA	NO
1991	29.76	NO	29.76	NA	NO
1992	32.16	NO	32.16	NA	NO
1993	35.10	NO	35.10	NA	NO
1994	38.40	NO	38.40	NA	NO
1995	41.93	NO	41.93	NA	NO
1996	45.67	NO	45.67	NA	NO
1997	49.57	NO	49.57	NA	NO
1998	52.36	NO	52.36	NA	NO
1999	55.85	NO	55.85	NA	NO
2000	59.60	NO	59.60	NA	NO
2001	61.76	NO	61.76	NA	NO
2002	64.01	NO	64.01	NA	NO
2003	66.33	NO	66.33	NA	NO
2004	68.74	NO	68.74	NA	NO
2005	71.24	NO	71.24	NA	NO
2006	73.43	NO	73.43	NA	NO
2007	75.70	NO	75.70	NA	NO
2008	81.09	0.56	80.53	NA	NO
2009	141.63	11.20	130.43	NA	NO

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$
2010	229.79	26.88	202.91	NA	NO
2011	232.17	26.88	205.29	NA	NO
2012	234.62	26.88	207.74	NA	NO
2013	250.30	29.29	221.01	NA	NO
2014	274.01	33.15	240.85	NA	NO
2015	258.32	29.79	228.52	NA	NO
2016	300.76	37.07	263.68	NA	NO
2017	362.32	47.84	314.49	NA	NO
Trend 1990 - 2017	*1160%*	-	*994%*		-
Trend 2005 - 2017	*409%*	-	*341%*		
Trend 2016 - 2017	*20%*	*29%*	*19%*		-

3.2.5.3.2 Methodological issues

3.2.5.3.2.1 Choice of methods for Coke oven coke production

For estimating the GHG emissions (CO_2, CH_4) the 2006 IPCC Guidelines Tier 1 approach[61] has been applied:

Equation 4.1: Emissions from coke production (2006 IPCC GL, Vol. 3, Chap. 4)

$$CO_2\ Emissions = Coke\ \times EF_{CO_2}$$

$$CH_4\ Emissions = Coke\ \times EF_{CH_4}$$

Where:

CO_2 Emissions	= emissions of CO_2 from coke production (tonnes CO_2)
CH_4 Emissions	= emissions of CH_4 from coke production (tonnes CH_4)
Coke	= amount of coke produced nationally (Gg)
EF_{CO2}	= default emission factor for CO_2 (tonnes CO_2/tonne coke production)
EF_{CH4}	= default emission factor for CH_4 (tonnes CH_4/tonne coke production)

Note:

- The Tier 1 method assumes that all of the coke oven by-products are transferred off site and that all of the coke oven gas produced is burned on site for energy recovery.
- It is assumed that no N_2O emissions arise from coke oven coke production.

[61] Source: 2006 IPCC Guidelines, Volume 3: Energy, Chapter 4: Metal Industry Emissions - 4.2.2.1 Choice of method: metallurgical coke production

Air pollutants emissions

For estimating the air pollutants emissions (NOx, CO, NMVOC, SO_2) from Coke oven coke production the Tier 1 approach[62] of the EMEP/EEA air pollutant emission inventory guidebook 2016 has been applied:

Chapter 5.4.2: Tier 1 default approach

$$\boldsymbol{Emissions_{pollutant} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{pollutant,\ fuel}}$$

Where:

$Emissions_{pollutant}$	= emissions of a given pollutant by type of fuel (kg pollutant)
$Fuel\ consumption_{fuel}$	= amount of coal consumed (Gg)
$Emission\ factor_{pollutant}$	= default emission factor of a given pollutant by type of fuel ($g_{pollutant}$/GJ).
Pollutant	= NOx, CO, NMVOC, SO_2

3.2.5.3.2.2 Choice of activity data for Coke oven coke production

The following fuels are considered as activity data for coke oven coke production:

Solid fuels:	Coking coal	for estimating GHG emissions
	Coke oven coke	for estimating Non-GHG emissions

Fuel consumption used for estimating the GHG and non-GHG emissions are taken for the years

- 2008 – 2017 from the UN Statistics Division (UNSD) - Energy Statistics Section.[63]

The national energy statistics do not provide data on coke oven coke production. Therefor the data used in the inventory were presented to and discussed with national experts from Ministry of Mining and Petroleum, National Statistic and Information Agency (NSIA) and Ministry of Energy and Water (MEW), National Protection Agency (NEPA). For the next inventory cycle the data will be reviewed in detail (see chapter 3.2.5.3.6 Planned improvements).

As Afghanistan has high quality coal like anthracite and coking coal the production and export of refined coal 'coke oven coal' started in 2008. From 2016 to 2017 the total fuel consumption increased by 29% due to increasing demand of coke oven coke production.

[62] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, 1.A.1 Energy industries, sub-chapter 5.4.2 Tier 1 default approach.

[63] Available (14 January 2019) on https://unstats.un.org/unsd/energy/default.htm

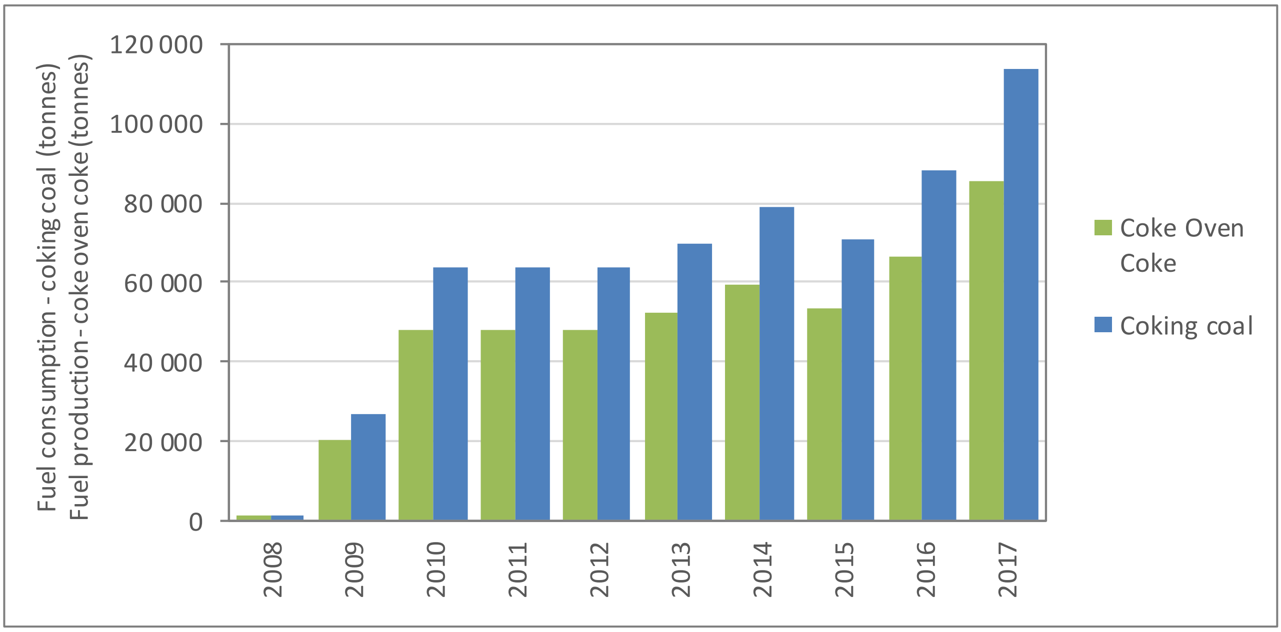


Figure 68 Activity data for IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels – Coke oven coke production

Table 77 Activity data for IPCC sub-category 1.A.1.c.i Manufacture of Solid - Coke oven coke production

Activity data 1.A.1.c.i Coke coven coal	Coke Oven Coke	Coking coal	
	t	t	TJ
1990	NO	NO	NO
⋮	⋮	⋮	⋮
2007	NO	NO	NO
2008	1 000	1 330	0.026
2009	20 000	26 600	0.516
2010	48 000	63 800	1.238
2011	48 000	63 800	1.238
2012	48 000	63 800	1.238
2013	52 300	69 500	1.349
2014	59 200	78 700	1.527
2015	53 200	70 800	1.373
2016	66 200	88 100	1.708
2017	85 426	113 686	2.204
Trend 1990 - 2017	-	-	-
Trend 2005 - 2017	-	-	-
Trend 2016 - 2017	*29%*	*29%*	*29%*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic metres. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.1.c.i *Manufacture of Solid Fuels* .

Table 78 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	2006 IPCC Guidelines Vol. 2, Chap. 1 (sub-chap. 1.4.1.3)
Coking coal	solid	25.80	D	Table 1.2 Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
Note: D Default CS Country specific PS Plant specific				

At this stage no more information was available about the coke oven production process. As coke oven coke production is a *key category* further analysis is needed with regards to

- raw material as input for coke oven process;
- fuel type and fuel consumption for coke oven heating;
- use of Coke Oven coke gas;
- national consumption of coke oven coke;
- use of by-products like coal tar and light oils.

In the following figure an illustration of the coke production process is provided.

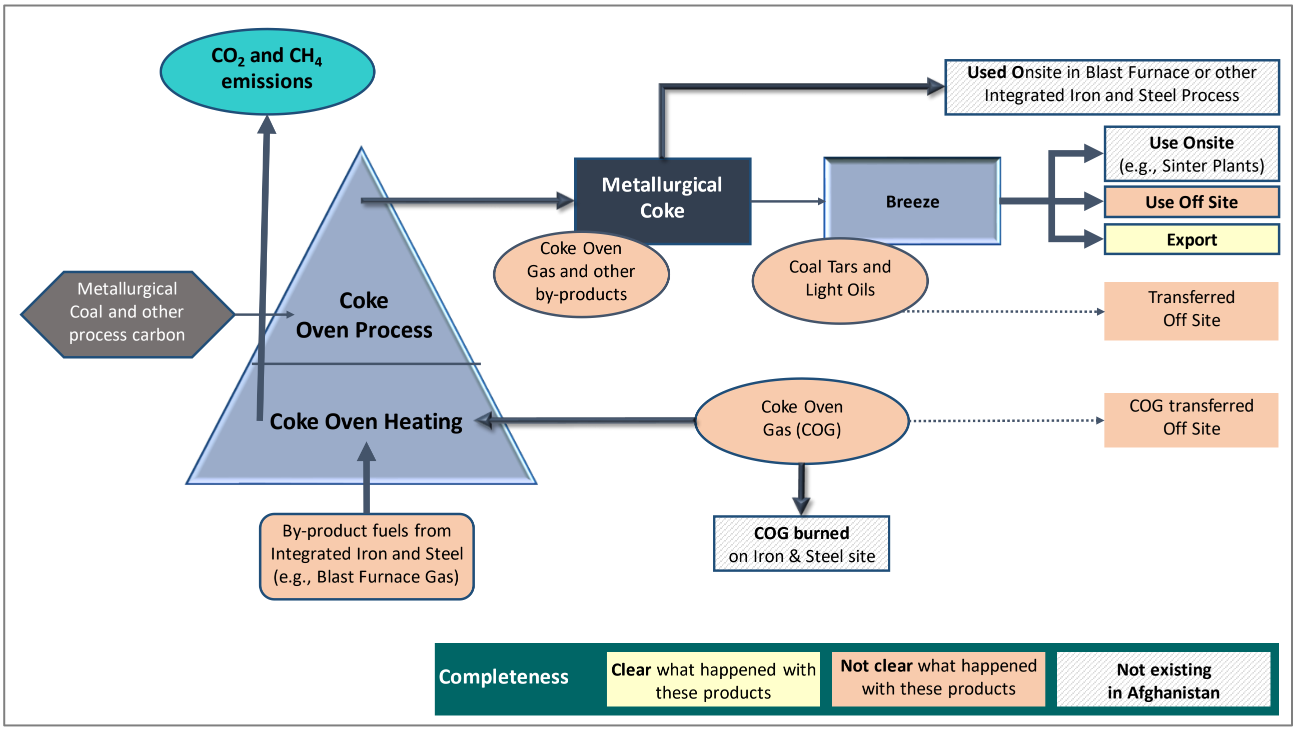


Figure 69 Illustration of coke production process

Source: 2006 IPCC Guidelines, Volume 3, Chapter 4: Metal Industry Emissions, Figure 4.2

3.2.5.3.2.3 Choice of emission factors for Coke oven coke production

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 79 GHG Emission factor TIER 1 for IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels

Process	CO_2 (tonne CO_2 per tonne coke produced)		CH_4 (tonne CH_4 per tonne coke produced)		Source
	EF	type	EF	type	2006 IPCC Guidelines Vol. 3, Chap. 4 (4.2.2.3)
Coke Oven	0.56	D			Table 4.1 TIER 1 default CO_2 emission factors for coke production and iron & steel production (page 4.25)
			0.1	D	Table 4.1 TIER 1 default CH_4 emission factors for coke production and iron & steel production (page 4.26)

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

Air pollutant emissions

Default emission factors for air pollutant were taken from the EMEP/EEA air pollutant emission inventory Guidebook 2016 and are presented in the following table.

Table 80 Non-GHG Emission factor for IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels – Coke Oven coke production

Fuel	Fuel type	NOx (g/GJ)		CO (g/GJ)		NMVOC (g/GJ)		SO_2 (g/GJ)		Source
		EF	type	EF	type	EF	type	EF	type	EMEP/EEA Guidebook 2016, Part B, Vol 1 - 1A, chap. 1.A.1
Coking coal	solid	21	D	6	D	0.8	D	91	D	Table 5-1 Tier 1 emission factors for source category 1.A.1.c (page. 59)

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.5.3.2.4 Choice of methods for Charcoal production

For estimating the GHG emissions (CH_4) the 2006 IPCC Guidelines Tier 1 approach[64] has been applied:

Emissions from Charcoal production

$$CH_4\ Emissions = Charcoal_{produced} \times EF_{CH_4}$$

Where:

CH_4 Emissions = emissions of CH_4 from charcoal production (Gg CH_4)
$Charcoal_{produced}$ = amount of charcoal produced nationally (Gg)
EF_{CH4} = default emission factor for CH_4 (kg/TJ of charcoal produced)

Note:

- It is assumed that no CO_2 and N_2O emissions arise from charcoal production.

[64] Source: 2006 IPCC Guidelines, Volume 3: Energy, Chapter 4: Metal Industry Emissions - 4.2.2.1 Choice of method: metallurgical coke production

Air pollutants emissions

For estimating the air pollutants emissions (NOx, CO, NMVOC, SO_2) from Coke oven coke production the Tier 1 approach[65] of the EMEP/EEA air pollutant emission inventory guidebook 2016 has been applied:

Chapter 5.4.2: Tier 1 default approach

$$\boldsymbol{Emissions_{pollutant} = Charcoal_{produced} \times Emission\ Factor_{pollutant}}$$

Where:

$Emissions_{pollutant}$	= emissions of a given pollutant (Gg pollutant)
$Charcoal_{produced}$	= amount of charcoal produced (Gg)
$Emission\ factor_{pollutant}$	= default emission factor of a given pollutant (kg/TJ of Charcoal Produced).
Pollutant	= NOx, CO, NMVOC, SO_2

Note:

- It is assumed that no SOx emissions arise from charcoal production.

3.2.5.3.2.5 Choice of activity data for Charcoal production

The following fuels are considered as activity data for coke oven coke production:

Solid fuels: Fuelwood
Charcoal

Fuel consumption used for estimating the GHG and non-GHG emissions are taken for all years from

- UN Statistics Division (UNSD) - Energy Statistics Section.[66]
- FAO statistics (as original source)

The national energy statistics do not provide data on charcoal production. Therefore, the data used in the inventory were presented to and discussed with national experts from Ministry of Mining and Petroleum, National Statistic and Information Agency (NSIA) and Ministry of Energy and Water (MEW), National Protection Agency (NEPA). For the next inventory cycle the data will be reviewed in detail (see chapter 3.2.5.3.6 Planned improvements).

[65] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, 1.A.1 Energy industries, sub-chapter 5.4.2 Tier 1 default approach.
[66] Available (17 December 2018) on https://unstats.un.org/unsd/energy/default.htm

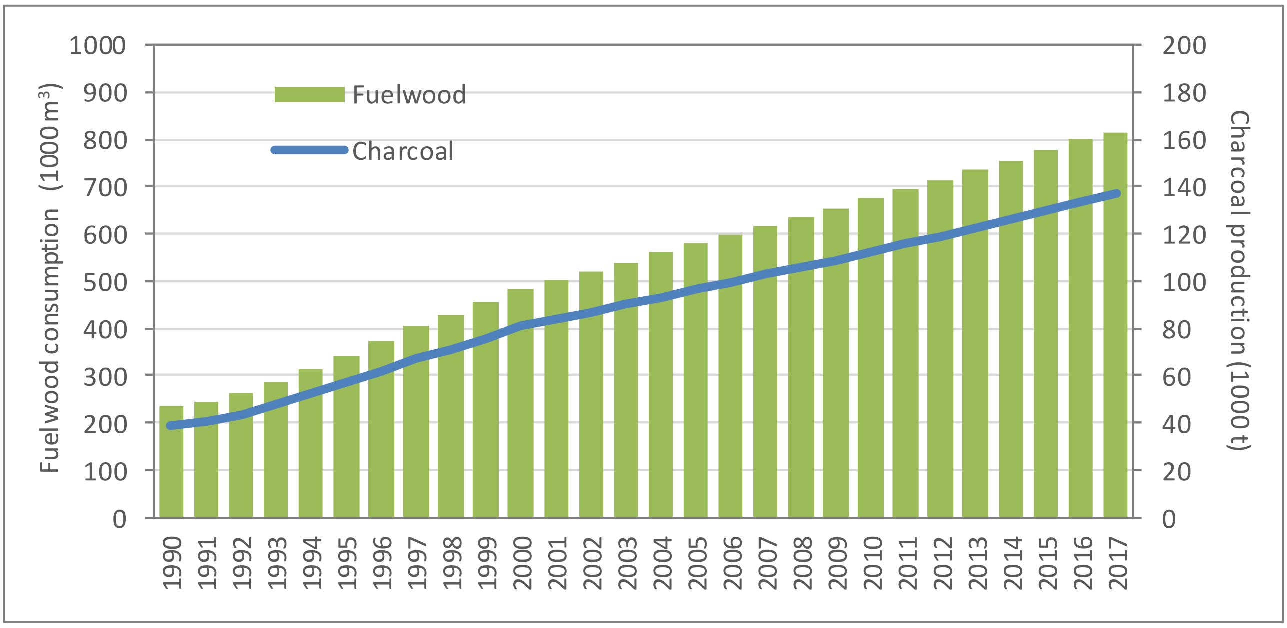


Figure 70 Activity data for IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels – Charcoal production

Table 81 Activity data for IPCC sub-category 1.A.1.c.i Manufacture of Solid - Charcoal production

Activity data 1.A.1.c.i Charcoal	Fuelwood	Charcoal	
	1000 m³	Gg	TJ
1990	233.964	38.994	1 150.323
1991	242.082	40.347	1 190.237
1992	261.666	43.611	1 286.525
1993	285.564	47.594	1 404.023
1994	312.432	52.072	1 536.124
1995	341.106	56.851	1 677.105
1996	371.538	61.923	1 826.729
1997	403.296	67.216	1 982.872
1998	425.994	70.999	2 094.471
1999	454.410	75.735	2 234.183
2000	484.866	80.811	2 383.925
2001	502.482	83.747	2 470.537
2002	520.740	86.790	2 560.305
2003	539.658	89.943	2 653.319
2004	559.266	93.211	2 749.725
2005	579.588	96.598	2 849.641
2006	597.432	99.572	2 937.374
2007	615.834	102.639	3 027.851
2008	634.794	105.799	3 121.071
2009	654.342	109.057	3 217.182
2010	674.490	112.415	3 316.243

Activity data 1.A.1.c.i Charcoal	Fuelwood	Charcoal	
	1000 m³	Gg	TJ
2011	693.876	115.646	3 411.557
2012	713.814	118.969	3 509.586
2013	734.328	122.388	3 610.446
2014	755.430	125.905	3 714.198
2015	777.144	129.524	3 820.958
2016	798.792	133.132	3 927.394
2017	813.141	136.841	4 036.810
Trend 1990 - 2017	*248%*	*251%*	*251%*
Trend 2005 - 2017	*40%*	*42%*	*42%*
Trend 2016 - 2017	*2%*	*3%*	*3%*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic metres. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.1.c.i *Manufacture of Solid Fuels*.

Table 82 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	2006 IPCC Guidelines Vol. 2, Chap. 1 (sub-chap. 1.4.1.3)
Wood/Wood Waste	Biomass	15.6	D	Table 1.2 Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
Charcoal	Biomass	29.50	D	
Note:				
D Default	CS Country specific	PS Plant specific		

3.2.5.3.2.6 Choice of emission factors for Charcoal production

Default emission factors for greenhouse gases were taken from Revised 1996 IPCC Guidelines, Reference Manual, and are presented in the following table.

Table 83 GHG Emission factor TIER 1 for IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels – Charcoal production

Process	CH_4 (kg/TJ of Charcoal Produced)		Source
	EF	Type	Revised 1996 IPCC Guidelines, Reference Manual, Chapter1 Energy (ch1 ref3.pdf)
Charcoal	1000	D	TABLE I-14 1 default non-CO_2 emission factors for charcoal production (page 1.46)
Note:			
D Default	CS Country specific	PS Plant specific	IEF Implied emission factor

Air pollutant emissions

Default emission factors for air pollutant were taken from the Revised 1996 IPCC Guidelines, Reference Manual, and are presented in the following table.

Table 84 Non-GHG Emission factor for IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels – Coke Oven coke production

Fuel	Fuel type	NOx (g/GJ)		CO (g/GJ)		NMVOC (g/GJ)		SO_2 (g/GJ)		Source
		EF	type	EF	type	EF	type	EF	type	**Revised 1996 IPCC Guidelines, Reference Manual, Chapter1 Energy (ch1 ref3.pdf)**
Charcoal	Biomass	10	D	7000	D	1700	D	NA	D	TABLE I-14 1 default non-CO_2 emission factors for charcoal production (page 1.46)

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.5.3.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.1.c.i Manufacture of Solid Fuels are presented in the following table.

Table 85 Uncertainty for IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels.

Uncertainty	Coke oven coke		Charcoal	Combined	Reference
	CO_2	CH_4	CH_4	CH_4	2006 IPCC GL
Activity data (AD)			60%		Vol. 2, Chap. 2.4.2 Activity data uncertainties
	10%	10%			Table 4.4, Vol. 3, Chap. 4.2.3
Emission factor (EF)	25%	25%			Table 4.4, Vol. 3, Chap. 4.2.3
			60%		Table 2.14, 2006 IPCC GL
Combined Uncertainty (U)	27%	27%	78%	83%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.2.5.3.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and international energy statistics of UN and FAO
⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;
⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;
⇒ time series consistency: plausibility checks of dips and jumps.

3.2.5.3.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category *1.A.1.c.i Manufacture of Solid Fuels* .

Table 86 Recalculations done since SNC in IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.1.c.i	No recalculation as this source is estimated the first time		

3.2.5.3.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 87 Planned improvements for IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.1.c.i	Cross-check of national and international data sources on coke oven coke production	AD	Consistency Transparency	high
1.A.1.c.i	Analysis of coke oven production • raw material as input for coke oven process; • fuel type and fuel consumption for coke oven heating; • use of Coke oven coke gas; • national consumption of coke oven coke; • use of by-products like coal tar and light oils.	AD	Accuracy Transparency Completeness	high
1.A.1.c.i	Country specific Net Caloric Value (NCV) for fuels of national production: coke oven coke ⇒ conversion from mass unit to energy unit (unit EF is kg /TJ)	AD EF	Accuracy Transparency	high
1.A.1.c.i	Carbon content (%) of coke oven coke for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox) / (NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	high
1.A.1.c.i	Sulphur content in used fuel for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{SO2}$** [g/GJ] = (S [%] • 20000) / (NCV [GJ/t])	EF non-GHG	Accuracy Transparency	low/ medium
1.A.1.c.i	Information about the combustion technologies used: information about the type of combustion plant (steam generator, gas turbine, dry bottom boiler etc.)	EF non-GHG	Accuracy Transparency	medium
1.A.1.c.i	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF non-GHG	Accuracy Transparency	low/ medium

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.1.c.i	Data obtained from measurements made on the emission of air polluters (NON-GHG inventory) • Determination of the o temperature in waste gases [°C]; o static pressure and the dynamic pressure [kPa]; o flow rate [m/s]; o volume flow rate [m^3/h and Nm^3/h]; o concentration of CO, SO_2, NOx in the exhaust gases [mg/Nm^3]; and • Gravimetric extraction of solid particles (TSP) from gases and determination by applying a gravimetric method (mg/Nm^3).	EF non-GHG	Accuracy Transparency	low/ medium
1.A.1.c.i	Cross-check of national and international data sources on charcoal production	AD	Consistency Transparency	high
1.A.1.c.i	Analysis of charcoal production (1) Raw materials for carbonization. • Fuelwood & wood fuel: type of wood and wood waste • Agricultural residues • bark waste (2) charcoal making technologies (3) efficiencies of various types of kiln			high
1.A.1.c.i	Country specific Net Caloric Value (NCV) for fuels of national production: charcoal ⇒ conversion from mass unit to energy unit (unit EF is kg /TJ)	AD EF	Accuracy Transparency	medium
1.A.1.c.i	Carbon content (%) of charcoal for preparing country specific emission factor (CS EF) ⇒ **CS EF_{CO2}** [t/TJ] = (C [%] • 44 • Ox) / (NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	medium

3.2.6 Manufacturing Industries and Construction (IPCC category 1.A.2)

This section describes GHG emissions resulting from fuel combustion activities in manufacturing industries and construction, which originate from the following sources:

IPCC code	Description	Occurrent		Not occurrent (NO)
		Estimated	Not estimated (NE)	
1.A.2.a	Iron and Steel	IE		
1.A.2.b	Non-Ferrous Metals	IE		
1.A.2.c	Chemicals	✓		
1.A.2.d	Pulp, Paper and Print	IE		
1.A.2.e	Food Processing, Beverages and Tobacco	IE		
1.A.2.f	Non-Metallic Minerals	IE		
1.A.2.g	Manufacturing of transport equipment			✓
1.A.2.h	Manufacturing of machinery			✓
1.A.2.i	Mining (excluding fuels) and Quarrying	IE		
1.A.2.j	Wood and wood products	IE		
1.A.2.k	Construction	IE		
1.A.2.l	Textile and Leather	IE		
1.A.2.m	Other	✓		
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential				

The national energy statistics currently do not provide information regarding the use of fuels in the different IPCC subcategories. Therefore, all emission except those for IPCC subcategory 1.A.2.c *Chemicals* are included in IPCC subcategory 1.A.2.m *Other*.

Energy used for transport by industry is reported but under IPCC category 1.A.3 Transport. GHG emissions arising from off-road and other mobile machinery in industry is also reported under IPCC category 1.A.3 Transport as there is no split in energy statistics.

However, for all subcategories of IPCC category 1.A.2 Manufacturing Industries and Construction the relevant activities including output is described. The relevant ISIC[67] Group is also provided.

[67] International Standard Industrial Classification of All Economic Activities, Revision 4 (UN ST/ESA/STAT/SER.M/4/Rev.4)
Source: Available (20 March 2019) on https://unstats.un.org/unsd/classifications/Econ/Download/In%20Text/ISIC_Rev_4_publication_English.pdf

3.2.6.1 Iron and Steel (IPCC category 1.A.2.a)

3.2.6.1.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.a	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE 1.A.2.a (all fuels) Energy statistics does not provide a split of the fuel combustion for this subcategory. Emissions are allocated in IPCC subcategory 1.A.2.m *Other*.

In Afghanistan the iron and steel industry produce steel from recycled steel scrap. The steel production takes place in electric induction furnaces - high frequency induction furnace with temperature of up to 1600 – 1700 °C. The charge of the furnace is 100 % steel scrap and no carbon electrodes are added. With regard to possible emissions, this means:

1.A.2.a Iron and Steel
- emission may occur due to onsite generation of electricity for the induction furnace.

2.C.1 Iron and Steel Production
- no appreciable CO_2 or CH_4 emissions from this steelmaking process.

According to the Ministry of Industry and Commerce (MoCI) the iron and steel producers (about 40) receive

- 65-70% of the electricity from the public electricity grid;
- 30-35% by onsite generation with generators combusting mazut which is fuel oil according to the nomenclature of the IPCC.

In the following figure the production of the iron and steel industry (ISIC Group 241 and Class 2431) (from recycled steel scrap) is presented.

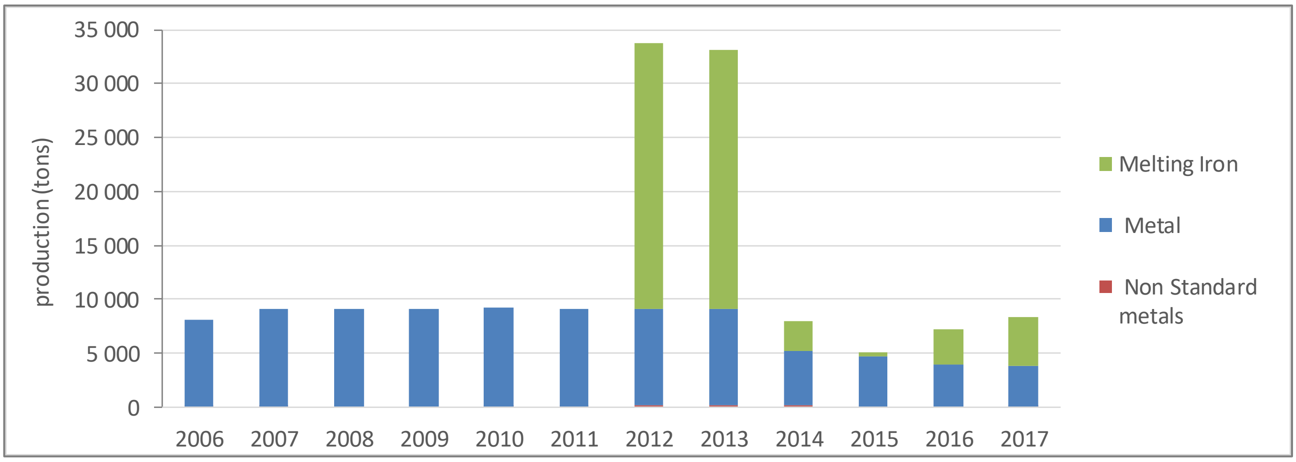


Figure 71 Production of Non-Standard metals, metal and Melting iron in the period 2006 – 2017

Source: NSIA: Afghanistan Statistical yearbook (All years).

3.2.6.1.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 88 Planned improvements for IPCC sub-category 1.A.2.b Non-Ferrous Metals

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.a	Analysis of the iron and steel industry • Annual consumption of fuel by type • Annual electricity consumption	AD	Accuracy Transparency Completeness	High
1.A.2.a	Cross-check of national and international data sources on charcoal production	AD	Consistency Transparency	medium

3.2.6.2 Non-Ferrous Metals (IPCC category 1.A.2.b)

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.b	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE	1.A.2.b (all fuels)	Energy statistics does not provide a split of the fuel combustion for this subcategory. Emissions are allocated in IPCC subcategory 1.A.2.m *Other*.

In Afghanistan, there might be (small) non-ferrous metals production from ore and/or scrap (ISIC Group 242 and Class 2432), but they could currently not be identified.

3.2.6.2.1 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 89 Planned improvements for IPCC sub-category 1.A.2.b Non-Ferrous Metals

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.b.	Analysis of Non-Ferrous Metals industry • annual amount of product produced • annual consumption of fuel by type • annual electricity consumption	AD	Accuracy Transparency Completeness	high

3.2.6.3 Chemical industry (IPCC category 1.A.2.c)

3.2.6.3.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.c	IE	NO	✓	NO	NO	NO	IE	NO	✓	NO	NO	NO	IE	NO	✓	NO	NO	NO
Key Category	-	-	LA 1990, 2017, TA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE 1.A.2.c (liquid fuels) Energy statistics does not provide a split of the fuel combustion in this subcategory. Emissions are allocated in IPCC subcategory 1.A.2.m Other.

This section describes GHG emissions resulting from fuel combustion activities in ammonia production (IPCC category 2.B.1) which originate from electricity and heat production plants (as auto-producer). Some amount of electricity is provided to the public.

Type of producer	Electricity plant	Heat plant	Remark
Main activity producer	• units that produce electricity or heat as their principal activity;		They may be in public or private ownership. Emissions from own on-site use of fuel are also included.
Auto-producer	• units that produces electricity but for which the production is not their principal activity;	• units that produce heat for sale but for which the production is not their principal activity;	

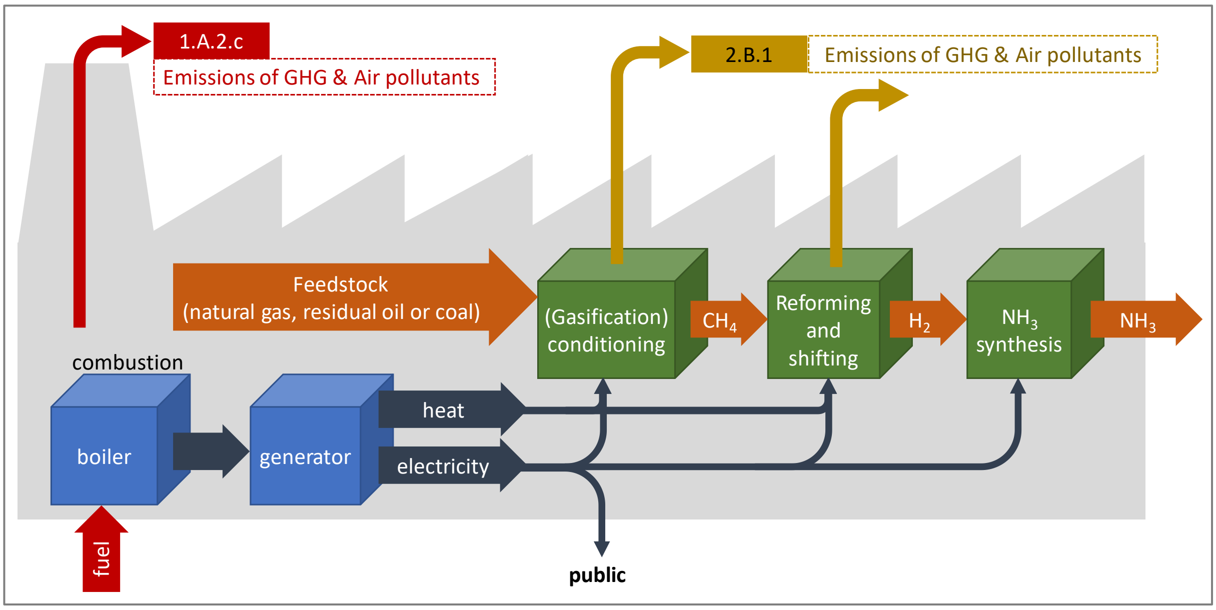


Figure 72 Schematic scheme of ammonia production

Power Plant at Kod-e-Barq

The Power Plant was built at the same time as the Fertilizer Plant (during the period from 1967 to 1973) primarily to provide power to the large number of compressors and pumps that the antiquated design Fertilizer Plant employs. It has a rated capacity of 48 MW, from four turbine generators of 12 MW each. The steam for the turbines is supplied by five water tube boilers run on gas.

In 2005, due to a shortage of gas and low power demand from the Fertilizer Plant, only three boilers are being operated, producing 45-50 Tons per hour of steam. Also, only three turbine generators are operating, generating 18MW of power. Of this, 16 MW is used in the Fertilizer Plant and the balance is supplied to factory housing.[68]

An overview of the GHG emission from fuel combustion in IPCC sub-category 1.A.2.c *Chemical industry* is provided in the following figure and table. The share in total GHG emissions from sector 1.A.2.c is 1.3% for the year 1990, 1.0% for the year 2005, and 0.4% for the year 2017.

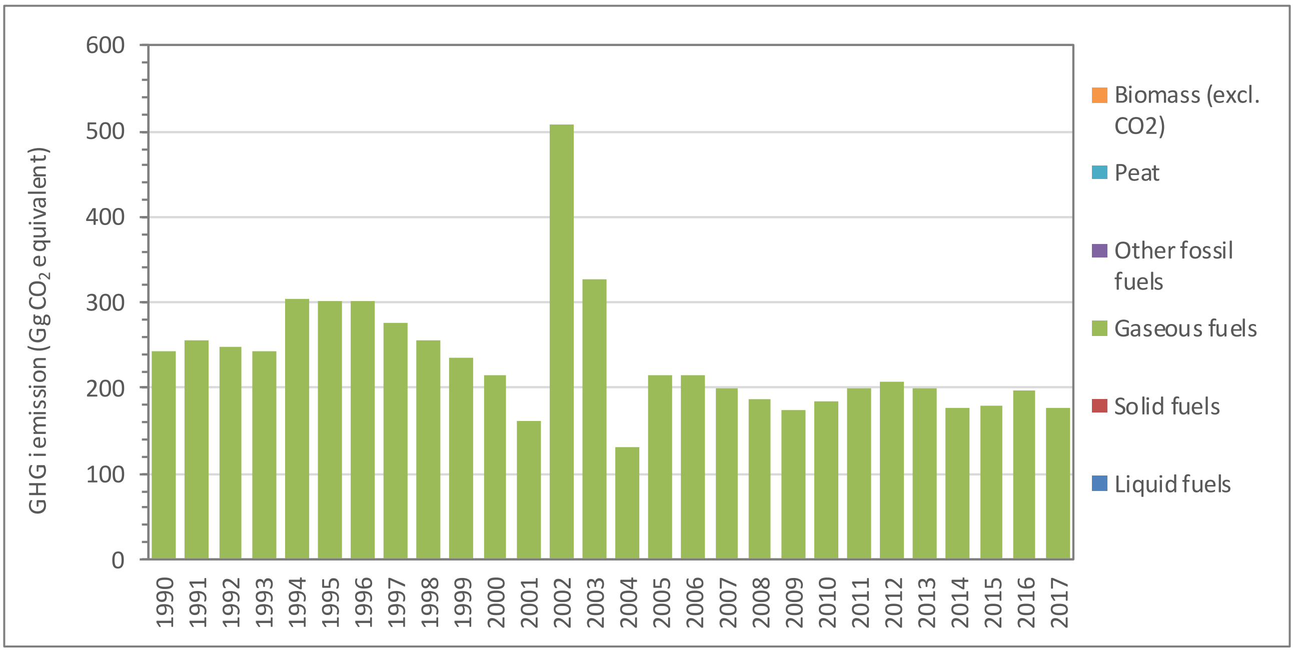


Figure 73 Emissions from IPCC sub-category 1.A.2.c Chemical industry

In the period 1990 to 2017 GHG emissions from sub-category 1.A.2.c decreased by -27.3% from 243.66 Gg CO_2 eq in 1990 to 177.05 Gg CO_2 eq in 2017. In the period 2005 to 2017 GHG emissions from sub-category 1.A.2.c decreased by -17.6%. The significant decrease of the GHG emissions and the fluctuation of the GHG emissions are mainly due to

[68] HILL INTERNATIONAL, INC. (2005): Evaluation of investment options for the development of oil and gas infrastructure in Afghanistan. Final Report. AFG/0361/TF 030397, Project No. PAG238/R BORHAN/REV.13; March 28, 2005, MAIN REPORT, **Chapter 4.0 Task 1B – Gas Processing and Fertilizer Plants**. Available (20 February 2019) on https://de.scribd.com/document/90145031/Task1B

- fuel shortage[69] and/or unlimited extraction (2002 & 2003)
- power plant is in poor condition due to age of the plant (constructed in 1967 to 1973) and lack of sufficient resources for both routine maintenance and for the type of capital projects which most plants require through their lives for betterment, upgrades and partial replacement of equipment;[70]
- shortage of natural gas due to damaged and/or destroyed pipelines;
- economic downturn due to the Afghan Civil War and War in Afghanistan.

As Afghanistan has only one ammonia plant, start-up and shut-down as well as maintenance periods are directly visible.

Table 90 Emissions from IPCC sub-category 1.A.2.c Chemical industry

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	243.65	243.43	0.09	0.13	NO
1991	256.70	256.46	0.10	0.14	NO
1992	249.01	248.78	0.09	0.14	NO
1993	242.69	242.46	0.09	0.13	NO
1994	303.83	303.55	0.11	0.17	NO
1995	301.42	301.14	0.11	0.17	NO
1996	301.14	300.86	0.11	0.17	NO
1997	275.87	275.62	0.10	0.15	NO
1998	255.66	255.42	0.10	0.14	NO
1999	235.44	235.22	0.09	0.13	NO
2000	215.10	214.90	0.08	0.12	NO
2001	160.61	160.47	0.06	0.09	NO
2002	507.85	507.38	0.19	0.28	NO
2003	327.67	327.37	0.12	0.18	NO
2004	131.08	130.96	0.05	0.07	NO
2005	214.85	214.65	0.08	0.12	NO
2006	215.82	215.62	0.08	0.12	NO
2007	200.35	200.16	0.07	0.11	NO
2008	187.98	187.80	0.07	0.10	NO
2009	174.33	174.17	0.07	0.10	NO
2010	184.67	184.50	0.07	0.10	NO
2011	200.52	200.34	0.07	0.11	NO
2012	206.81	206.61	0.08	0.11	NO
2013	199.05	198.87	0.07	0.11	NO

[69] HILL INTERNATIONAL, INC. (2005): **Chapter 2.3 Status of Oil and Gas Infrastructure.**

[70] USAID (2011): Engineering support program. WO-LT-0024 Kud Bergh (Mazar) 48MW Power Plant Field Investigation Interim Report – Options for Refurbishment and Replacement of Power Plant – 2011. Washington. Available (25 February 2019) on https://files.globalwaters.org/water-links-files/Final%20Performance%20Evaluation%20-%20Afghan%20Engineering%20Support%20Program.pdf

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
2014	176.95	176.79	0.07	0.10	NO
2015	179.34	179.17	0.07	0.10	NO
2016	197.07	196.89	0.07	0.11	NO
2017	177.04	176.88	0.07	0.10	NO
Trend 1990 - 2017	*-27%*	*-27%*	*-27%*	*-27%*	-
Trend 2005 - 2017	*-18%*	*-18%*	*-18%*	*-18%*	-
Trend 2016 - 2017	*-10%*	*-10%*	*-10%*	*-10%*	-

3.2.6.3.2 Methodological issues

3.2.6.3.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[71] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

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

Where:

Emissions $_{GHG,\ fuel}$ = emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$ = amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$ = default emission factor of a given GHG by type of fuel (kg gas/TJ)
For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG = CO_2, CH_4, N_2O

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{\mathrm{GHG,\,fuel}}}$$

Air pollutants emissions

For estimating the air pollutants emissions (NO_x, CO, NMVOC, SO_2) the Tier 1 approach[72] of the EMEP/EEA air pollutant emission inventory guidebook 2016 has been applied:

Equation: Air pollutant emissions from stationary combustion

$$\boldsymbol{Emissions_{pollutant} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{pollutant,\,fuel}}$$

Where:

Emissions $_{pollutant}$ = emissions of a given pollutant by type of fuel (kg pollutant)
Fuel consumption $_{fuel}$ = amount of fuel combusted (TJ)
Emission factor $_{pollutant,\ fuel}$ = default emission factor of a given pollutant by type of fuel (g $_{pollutant}$/GJ).
Pollutant = NOx, CO, NMVOC, SO_2

[71] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

[72] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, 1.A.2 Manufacturing industries and construction (combustion), sub-chapter 3.2.2 Tier 1 default approach.

3.2.6.3.2.2 Choice of activity data

The following fuels are used for electricity production:

Gaseous fuels:	Natural Gas
Liquid fuels:	IE - Included in 1.A.2.m Other

Natural gas is used in one power plant which is mainly serving the Northern Fertilizer Power Plant (NFPP) in Mazar-e-Sharif. The Northern Fertilizer Power Plant (NFPP) is an auto-producer which is also provides electricity to the public. As the principal activity is fertilizer production, the activity data and emissions are included in IPCC sub-category 1.A.2.c *Chemicals* and IPCC sub-category *2.B.1 Ammonia Production.*

Fuel consumption used for estimating the GHG and non-GHG emissions are taken for the years

- 2005 – 2017 from National Statistics and Information Authority (NSIA), Table 9-13 : Quantity and Value of Mining and Quarrying and National Statistical Yearbook (various years)
- 1990 – 2004 from the UN Statistics Division (UNSD) - Energy Statistics Section. The data are declared (by UNSD) as official data.

The activity data are **calculated data** based on “backwards calculation” from urea production applying default factors for

- total fuel requirement (GJ(NCV)/tonne NH3)
- carbon content factor (kg/GJ)
- carbon oxidation factor of the fuel (fraction)
- CO_2 recovered for downstream use (urea production) (kg)
- conversion of NH3 and CO_2 to urea (tonnes of CO_2/per tonne of urea produced).

Detailed description of the amount of natural gas used as feedstock and as fuel is provided in chapter 4.2.1 Ammonia Production (IPCC subcategory 2.B.1).

The total fuel consumption decreased by 28% in the period 1990 - 2017 and by 19% in the period 2005 - 2017. From 2016 to 2017 the total fuel consumption increased by 11% due to increasing demand of electricity. As mentioned above, the fluctuation of the fuel consumption is mainly due fuel shortage and/or unlimited extraction.

As Afghanistan has only one ammonia plant, start-up, shut-down and maintenance periods are visible.

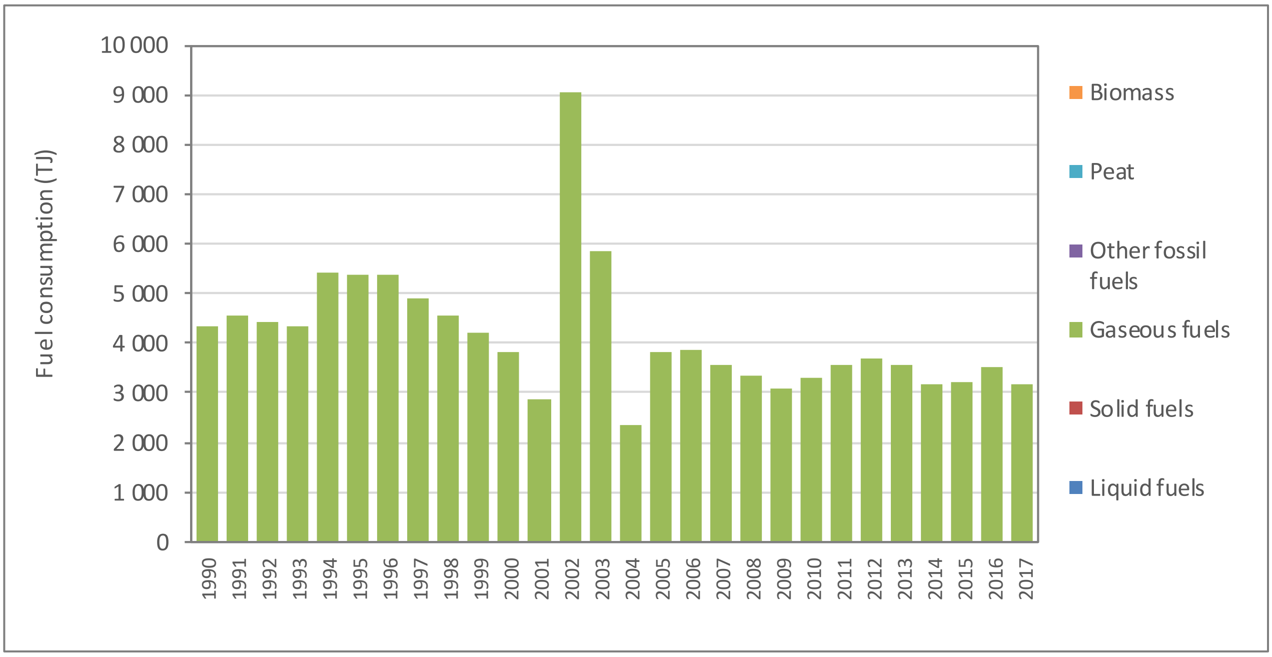


Figure 74 Activity data for IPCC sub-category 1.A.2.c Chemical industry

Table 91 Activity data for IPCC sub-category 1.A.2.c Chemical industry

Activity data 1.A.2.c	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels *(calculated)*	Other fossil fuels	Peat	Biomass
	TJ						
1990	4 339	IE	NO	4 339	NO	NO	NO
1991	4 572	IE	NO	4 572	NO	NO	NO
1992	4 435	IE	NO	4 435	NO	NO	NO
1993	4 322	IE	NO	4 322	NO	NO	NO
1994	5 411	IE	NO	5 411	NO	NO	NO
1995	5 368	IE	NO	5 368	NO	NO	NO
1996	5 363	IE	NO	5 363	NO	NO	NO
1997	4 913	IE	NO	4 913	NO	NO	NO
1998	4 553	IE	NO	4 553	NO	NO	NO
1999	4 193	IE	NO	4 193	NO	NO	NO
2000	3 831	IE	NO	3 831	NO	NO	NO
2001	2 860	IE	NO	2 860	NO	NO	NO
2002	9 044	IE	NO	9 044	NO	NO	NO
2003	5 835	IE	NO	5 835	NO	NO	NO
2004	2 334	IE	NO	2 334	NO	NO	NO
2005	3 826	IE	NO	3 826	NO	NO	NO
2006	3 843	IE	NO	3 843	NO	NO	NO
2007	3 568	IE	NO	3 568	NO	NO	NO
2008	3 348	IE	NO	3 348	NO	NO	NO
2009	3 105	IE	NO	3 105	NO	NO	NO
2010	3 289	IE	NO	3 289	NO	NO	NO

Activity data 1.A.2.c	**Total fuels** (incl. biomass)	**Liquid fuels**	**Solid fuels**	**Gaseous fuels** *(calculated)*	**Other fossil fuels**	**Peat**	**Biomass**
	TJ						
2011	3 571	IE	NO	3 571	NO	NO	NO
2012	3 683	IE	NO	3 683	NO	NO	NO
2013	3 545	IE	NO	3 545	NO	NO	NO
2014	3 151	IE	NO	3 151	NO	NO	NO
2015	3 194	IE	NO	3 194	NO	NO	NO
2016	3 510	IE	NO	3 510	NO	NO	NO
2017	3 153	IE	NO	3 153	NO	NO	NO
Trend							
1990 - 2017	*-27%*	-	-	*-27%*	-	-	-
2005 - 2017	*-18%*	-	-	*-18%*	-	-	-
1990 - 2017	*-10%*	-	-	*-10%*	-	-	-

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tons or cubic metres. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.2.c Chemical industry.

Table 92 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.2.c Chemical industry

Fuel	**Fuel type**	**Net calorific value (NCV) (TJ/Gg)**		**Source**
		NCV	**type**	
Natural gas	Gaseous	15.3	D	**2006 IPCC Guidelines, Vol. 2, Chap. 1, Table 1.2** Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
Note: D Default CS Country specific PS Plant specific				

3.2.6.3.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 93 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2.c Chemical industry

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Natural gas	gaseous	74 100	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

Default emission factors for air pollutant were taken from the EMEP/EEA air pollutant emission inventory Guidebook 2016 and are presented in the following table.

Table 94 Non-GHG Emission factor for IPCC sub-category 1.A.2.c Chemical industry

Fuel	Fuel type	NOx (g/GJ)		CO (g/GJ)		NMVOC (g/GJ)		SO_2 (g/GJ)		Source
		EF	Type	EF	type	EF	type	EF	type	EMEP/EEA Guidebook 2016, Part B, Vol 1 - 1A, chap. 1.A.2
Natural gas	gaseous	74	D	29	D	23	D	0.67	D	**Table 3-3** Tier 1 emission factors for 1.A.2 combustion in industry using gaseous fuels (page. 16)

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.6.3.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.2.c Chemical industry are presented in the following table.

Table 95 Uncertainty for IPCC sub-category 1.A.2.c Chemical industry.

Uncertainty	Liquid fuels			Reference
	CO_2	CH_4	N_2O	2006 IPCC GL, Vol. 2, Chap. 2 (2.4.2)
Activity data (AD)	10%	10%	10%	Table 2.15 and Table 3.1
Emission factor (EF)	20%			Table 2.13
		100%		Table 2.12
			20%	Table 2.14
Combined Uncertainty (U)	22%	100%	22%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.2.6.3.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic (CSO/NSIA) and international energy statistics of UN, FAO statistics (fertilizer production)

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.3.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category 1.A.2.c *Chemical industry* and 2.B.1 *Ammonia production.*

Table 96 Recalculations done since SNC in IPCC sub-category 1.A.2.c Chemical industry

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.2.c 2.B.2	Consumption of natural gas (activity data) for ammonia plant was completely allocate in 1.A.2.m. It was also assumed that the • entire amount of natural gas was burned; • no natural gas was used as feedstock (non-energy use); • no CO_2 recovery for downstream process – urea production.	AD	Accuracy Transparency Comparability
1.A.2.c, 2.B.2	Reallocation of fuel consumption (natural gas, solid fuels) to relevant subcategories – 1.A.2	AD	Transparency Comparability
1.A.2.c, 2.B.2	use of default NCV of 2006 IPCC Guidelines	AD	Comparability
1.A.2.c, 2.B.2	use of default EF of 2006 IPCC Guidelines	EF	Comparability
1.A.2.c, 2.B.2	application of 2006 IPCC Guidelines	method	Comparability

3.2.6.3.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 97 Planned improvements for IPCC sub-category 1.A.2.c Chemical industry

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.c, 2.B.1	Analysis of interdependency of different inorganic chemical processes of the fertilizer plant (see chapter 4.2.1)	AD EF	Completeness Transparency	high
1.A.2.c, 2.B.1	Survey on fuel used (natural gas, liquid fuels etc.) in power plant: • annual amount of fuel consumption for combustion • annual amount of feedstock / Total fuel requirement (GJ(NCV)/tonne NH3)	AD	Completeness Transparency	high
1.A.2.c, 2.B.1	Cross-check of national and international data sources and feedback to UNSD	AD	Consistency Transparency	medium
1.A.2.c, 2.B.1	Country specific Net Caloric Value (NCV) for used fuels: natural gas ⇒ conversion from mass unit to energy unit (unit EF is kg /TJ)	AD EF	Accuracy Transparency	medium
1.A.2.c, 2.B.1	Carbon content (%) of used fuels - natural gas etc. - for preparing country specific emission factor (CS EF) ⇒ **CS EF_{CO2}** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	medium
1.A.2.c	Sulphur content in used fuel for preparing country specific emission factor (CS EF) ⇒ **CS EF_{SO2}** [g/GJ] = (S [%] • 20000) / (NCV [GJ/t])	EF non-GHG	Accuracy Transparency	medium
1.A.2.c	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF non-GHG	Accuracy Transparency	medium
1.A.2.c	Data obtained from measurements made on the emission of air polluters (NON-GHG inventory) • Determination of the o temperature in waste gases [°C]; o static pressure and the dynamic pressure [kPa]; o flow rate [m/s]; o volume flow rate [m^3/h and Nm^3/h]; o concentration of CO, SO_2, NOx in the exhaust gases [mg/Nm^3]; and • Gravimetric extraction of solid particles (TSP) from gases and determination by applying a gravimetric method (mg/Nm^3).	EF non-GHG	Accuracy Transparency	medium

3.2.6.4 Pulp, Paper and Print (IPCC category 1.A.2.d)

3.2.6.4.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.d	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE 1.A.2.d (all fuels)	Energy statistics does not provide a split of the fuel combustion in this subcategory. Emissions are allocated in IPCC subcategory 1.A.2.m *Other*.	

The IPCC subcategory 1.A.2.d Pulp, Paper and Print includes the

(1) Manufacture of paper and paper products (ISIC Group 17)
- Manufacture of pulp, paper and paperboard
- Manufacture of corrugated paper and paperboard and of containers of paper and paperboard
- Manufacture of other articles of paper and paperboard

(2) Printing and reproduction of recorded media (ISIC Group 18)
- Printing
- Service activities related to printing
- Reproduction of recorded media

In the following figure the products of the Pulp, Paper and Print industry (ISIC Group 17 and 18) is presented.

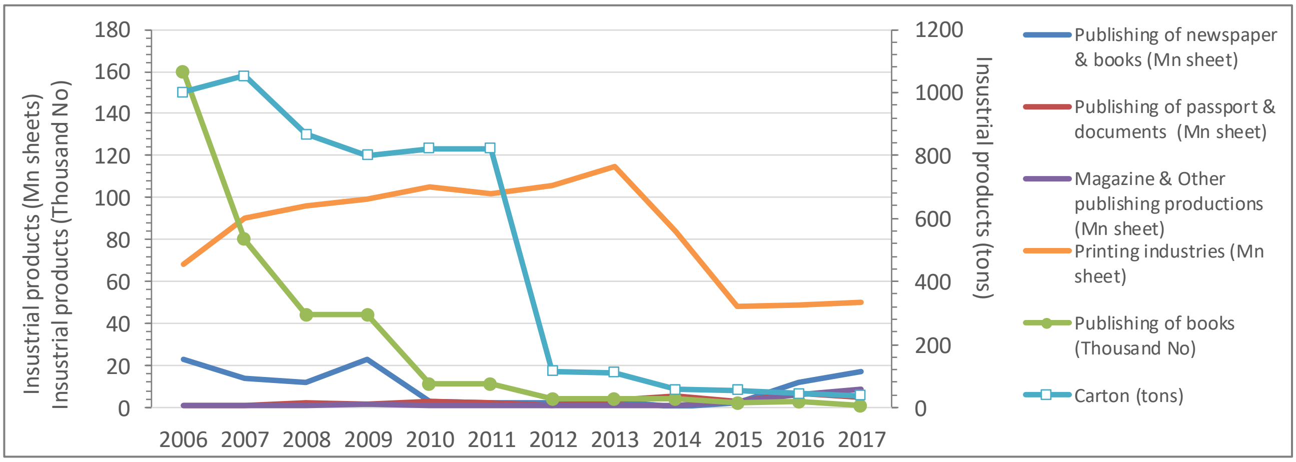


Figure 75 Products of the Pulp, Paper and Printing Industry in the period 2006 – 2017

Source: NSIA: Afghanistan Statistical yearbook (All years).

3.2.6.4.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 98 Planned improvements for IPCC sub-category 1.A.2.d Pulp, Paper and Print

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.d	Analysis of pulp, paper and print industry • annual amount of product produced • annual consumption of fuel by type • annual electricity consumption	AD	Accuracy Transparency Completeness	high

3.2.6.5 Food Processing, Beverages and Tobacco (IPCC category 1.A.2.e)

3.2.6.5.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.e	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

<u>Use of notation key</u>

IE	1.A.2.e (all fuels)	Energy statistics does not provide a split of the fuel combustion in this subcategory. Emissions are allocated in IPCC subcategory 1.A.2.m *Other*.

The IPCC subcategory 1.A.2.e Food Processing, Beverages and Tobacco includes the

(1) Manufacture of food products (ISIC Group 10)

- Processing and preserving of
  - meat
  - fish, crustaceans and molluscs
  - fruit and vegetables
- Manufacture of
  - vegetable and animal oils and fats
  - dairy products
  - grain mill products
  - starches and starch products
  - bakery products
  - sugar
  - cocoa, chocolate and sugar confectionery
  - macaroni, noodles, couscous and similar farinaceous products
  - prepared meals and dishes
  - other food products n.e.c.
  - prepared animal feeds

(2) Manufacture of beverages (ISIC Group 11)

- Distilling, rectifying and blending of spirits
- Manufacture of
  - wines
  - malt liquors and malt
  - soft drinks; production of mineral waters and other bottled waters

(3) Manufacture of tobacco products (ISIC Group 12)

In the following figure the products of the Food Processing, Beverages and Tobacco industry (ISIC Group 10, 11 and 12) is presented.

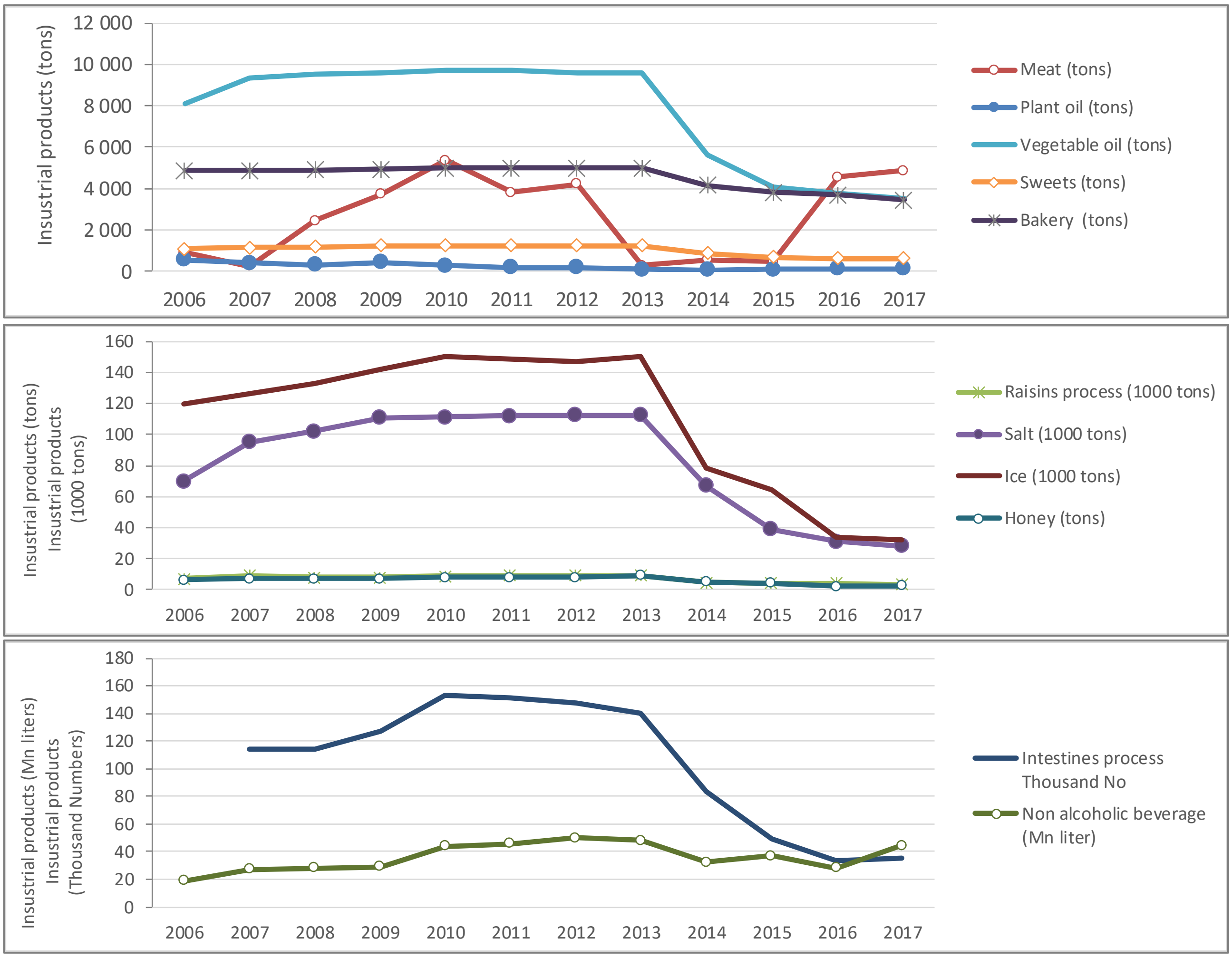


Figure 76 Products of the Food Processing, Beverages and Tobacco in the period 2006 – 2017

Source: NSIA: Afghanistan Statistical yearbook (All years).

3.2.6.5.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 99 Planned improvements for IPCC sub-category 1.A.2.e Food Processing, Beverages and Tobacco

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.e	Analysis of pulp, paper and print industry • annual amount of product produced • annual consumption of fuel by type • annual electricity consumption	AD	Accuracy Transparency Completeness	high

3.2.6.6 Non-Metallic Minerals (IPCC category 1.A.2.f)

3.2.6.6.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.f	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

<u>Use of notation key</u>

IE	1.A.2.f (all fuels)	Energy statistics does not provide a split of the fuel combustion in this subcategory. Emissions are allocated in IPCC subcategory 1.A.2.m *Other*.

Afghanistan produces cement and lime. The production of cement and Lime involves broadly the following stages:

- mining/extraction and pre-processing of raw materials;
- pyro-processing (calcination) to produce clinker / calcining of the limestone;
- blending and grinding of clinker to cement / posttreatment;
- storage, packing and delivery.

Especially the calcination is an energy-intensive process as temperature of 1,400 – 1,500˚C need to be reached.

The IPCC subcategory 1.A.2.f Non-Metallic Minerals includes

- Manufacture of
  - glass and glass products
  - refractory products
  - clay building materials
  - other porcelain and ceramic products
  - cement, lime and plaster
  - articles of concrete, cement and plaster
  - other non-metallic mineral products n.e.c.
- Cutting, shaping and finishing of stone

In the following figure the products of the Non-Metallic Minerals industry (ISIC Group 23) is presented.

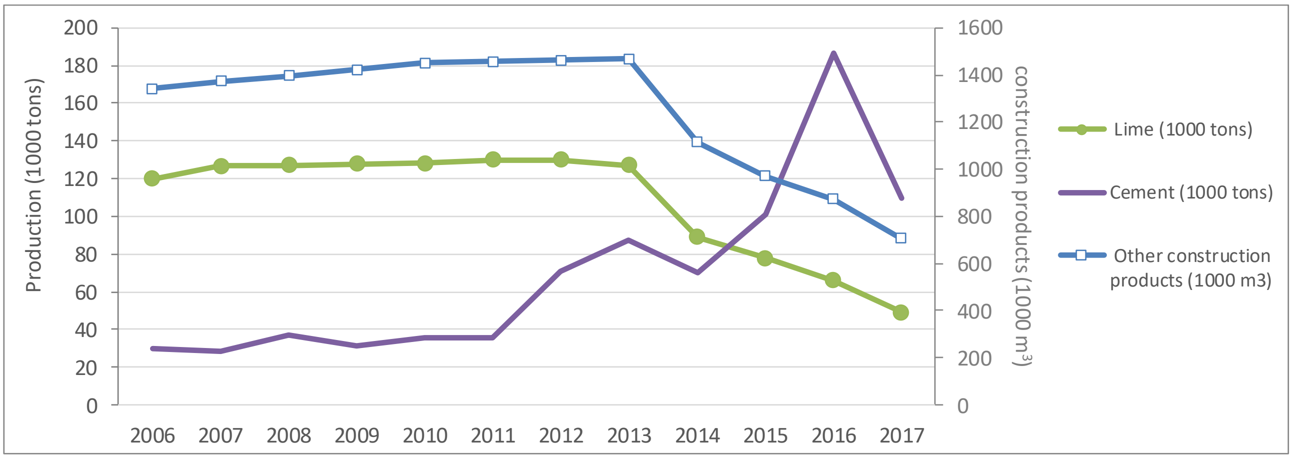


Figure 77 **Production of cement, lime and other construction products in the period 2006 – 2017**

Source: NSIA: Afghanistan Statistical yearbook (All years).

3.2.6.6.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 100 **Planned improvements for IPCC sub-category 1.A.2.f Non-Metallic Minerals**

GHG source & sink category	Planned improvement	Type of improvement		Priority

1.A.2.f	Analysis of Non-Metallic Minerals industry
	• annual amount of product produced, especially with regards to
	  ○ clay building materials,
	  ○ other porcelain and ceramic products,
	  ○ articles of concrete, cement and plaster
	• annual cutting, shaping and finishing of stone activities
	• annual consumption of fuel by type
	• annual electricity consumption
		AD	Accuracy
			Transparency
			Completeness
				high

3.2.6.7 Manufacturing of transport equipment (IPCC category 1.A.2.g)

3.2.6.7.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.g	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

The IPCC subcategory 1.A.2.f *Manufacturing of transport equipment* (ISCS 29 and 30) includes

- Manufacture of motor vehicles, trailers and semi-trailers
- Building of ships and boats (ships and floating structures, pleasure and sporting boats
- Manufacture of railway locomotives and rolling stock
- Manufacture of air and spacecraft and related machinery
- Manufacture of military fighting vehicles
- Manufacture of transport equipment (motorcycles, bicycles and invalid carriages, other transport equipment n.e.c.)

In Afghanistan, none of these activities could be identified.

3.2.6.7.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 101 Planned improvements for IPCC sub-category 1.A.2.g Manufacturing of transport equipment

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.g	Analysis of Manufacturing of transport equipment • annual quantities of product produced • annual consumption of fuel by type • annual electricity consumption	AD	Accuracy Transparency Completeness	high

3.2.6.8 Manufacturing of machinery (IPCC category 1.A.2.h)

3.2.6.8.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.h	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

The IPCC subcategory 1.A.2.h *Manufacturing of machinery* (ISCS 28) includes

(1) Manufacture of general-purpose machinery

- Manufacture of
  - engines and turbines, except aircraft, vehicle and cycle engines
  - fluid power equipment
  - other pumps, compressors, taps and valves
  - bearings, gears, gearing and driving elements
  - ovens, furnaces and furnace burners
  - lifting and handling equipment
  - office machinery and equipment
  - power-driven hand tools
  - other general-purpose machinery

(2) Manufacture of special-purpose machinery

- Manufacture of
  - agricultural and forestry machinery
  - metal-forming machinery and machine tools
  - machinery for metallurgy
  - machinery for mining, quarrying and construction
  - machinery for food, beverage and tobacco processing
  - machinery for textile, apparel and leather production

In Afghanistan, none of these activities could be identified.

3.2.6.8.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 102 Planned improvements for IPCC sub-category 1.A.2.h Manufacturing of machinery

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.h	Analysis of industry 'Manufacturing of machinery' • annual quantities of product produced • annual consumption of fuel by type • annual electricity consumption	AD	Accuracy Transparency Completeness	High

3.2.6.9 Mining (excluding fuels) and Quarrying (IPCC category 1.A.2.i)

3.2.6.9.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.i	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE	1.A.2.i (all fuels)	Energy statistics does not provide a split of the fuel combustion in this subcategory. Emissions are allocated in IPCC subcategory 1.A.2.m *Other*.

The IPCC subcategory 1.A.2.i *Mining (excluding fuels) and Quarrying* (ISCI 8 and 9) includes:

(1) Other mining and quarrying
- Quarrying of stone, sand and clay
- Mining and quarrying n.e.c.
- Mining of chemical and fertilizer minerals
- Extraction of peat
- Extraction of salt
- Other mining and quarrying n.e.c.

(2) Mining support service activities
- Support activities for petroleum and natural gas extraction
- Support activities for other mining and quarrying

In the following figure the products of the Mining (excluding fuels) and Quarrying activities (ISIC Group 8 and 9) are presented.

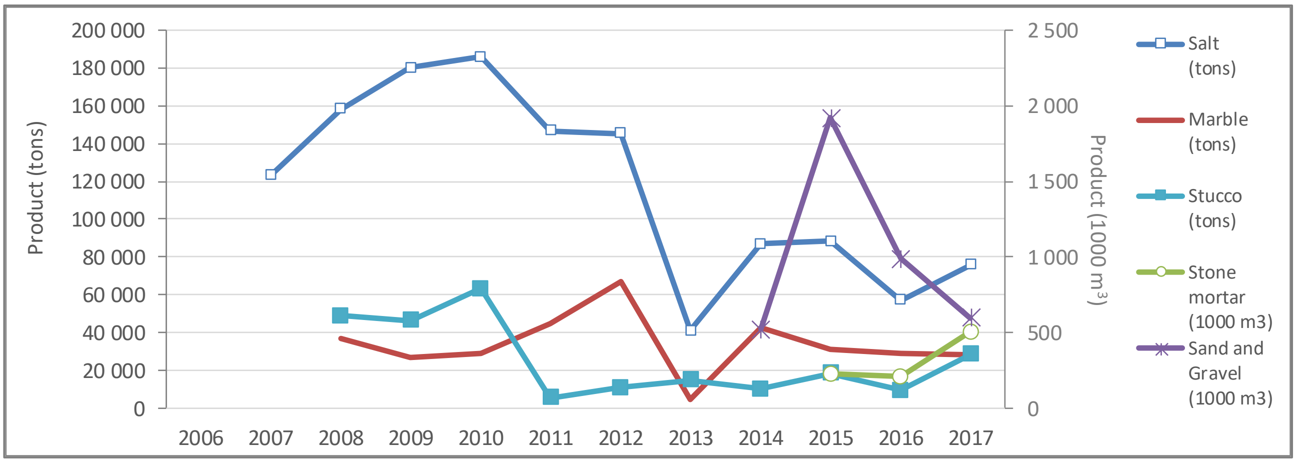


Figure 78 Mining and quarrying product: Salt, marble, stucco, stone mortar, sand and gravel in the period 2006 – 2017

Source: NSIA: Afghanistan Statistical yearbook (All years).

3.2.6.9.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 103 Planned improvements for IPCC sub-category 1.A.2.i Mining (excluding fuels) and Quarrying

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.f	Analysis of mining industry and related quarrying activities • annual quantity of product mined and quarried • annual cutting, shaping and finishing of stone activities • annual consumption of fuel by type • annual electricity consumption	AD	Accuracy Transparency Completeness	high

3.2.6.10 Wood and wood products (IPCC category 1.A.2.j)

3.2.6.10.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.j	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

<u>Use of notation key</u>

IE	1.A.2.j (all fuels)	Energy statistics does not provide a split of the fuel combustion in this subcategory. Emissions are allocated in IPCC subcategory 1.A.2.m *Other*.

The IPCC subcategory 1.A.2.j *Wood and wood products* (ISCI 16) includes:

(1) Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
- Sawmilling and planning of wood
- Manufacture of products of wood, cork, straw and plaiting materials
- Manufacture of veneer sheets and wood-based panels
- Manufacture of builders' carpentry and joinery
- Manufacture of wooden containers
- Manufacture of other products of wood.

Wood industry and manufacture of wood products is occurring in Afghanistan, nut (ISIC Group 242 and Class 2432), but they could currently not be identified.

3.2.6.10.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 104 Planned improvements for IPCC sub-category 1.A.2.j Wood and wood products

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.j	Analysis of Wood industry & manufacture of wood products • annual quantity of products •	AD	Accuracy Transparency Completeness	high

3.2.6.11 Construction (IPCC category 1.A.2.k)

3.2.6.11.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.k	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE	1.A.2.k (all fuels)	Energy statistics does not provide a split of the fuel combustion for this subcategory. Emissions are allocated in IPCC subcategory 1.A.2.m *Other*.

The IPCC subcategory 1.A.2.k *Construction* (ISCI 41) includes Construction of buildings, which is occurring in Afghanistan.

3.2.6.11.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 105 Planned improvements for IPCC sub-category 1.A.2.k Construction

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.k	Analysis of Construction industry • number off-road machines and operation activities • fuel combustion of off-road machines • construction activities (infrastructure, buildings, etc.)	AD	Accuracy Transparency Completeness	high

3.2.6.12 Textile and Leather (IPCC category 1.A.2.l)

3.2.6.12.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.l	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO	IE	IE	NO	IE	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE 1.A.2.l (all fuels) Energy statistics does not provide a split of the fuel combustion for this subcategory. Emissions are allocated in IPCC subcategory 1.A.2.m *Other*.

The IPCC subcategory 1.A.2.l *Textile and Leather* includes:

(1) Manufacture of textiles

- Spinning, weaving and finishing of textiles
- Preparation and spinning of textile fibres
- Weaving of textiles
- Finishing of textiles
- Manufacture of knitted and crocheted fabrics
- Manufacture of made-up textile articles, except apparel
- Manufacture of carpets and rugs
- Manufacture of cordage, rope, twine and netting
- Manufacture of other textiles n.e.c.
- Manufacture of made-up textile articles, except apparel

(2) Manufacture of wearing apparel

- Manufacture of wearing apparel, except fur apparel
- Manufacture of articles of fur
- Manufacture of knitted and crocheted apparel

(3) Manufacture of leather and related products

- Tanning and dressing of leather; dressing and dyeing of fur
- Manufacture of footwear
- Manufacture of luggage, handbags and the like, saddlery and harness

In the following figure the products of the Textile and Leather Industry (ISIC Group 13, 14, and 15) are presented.

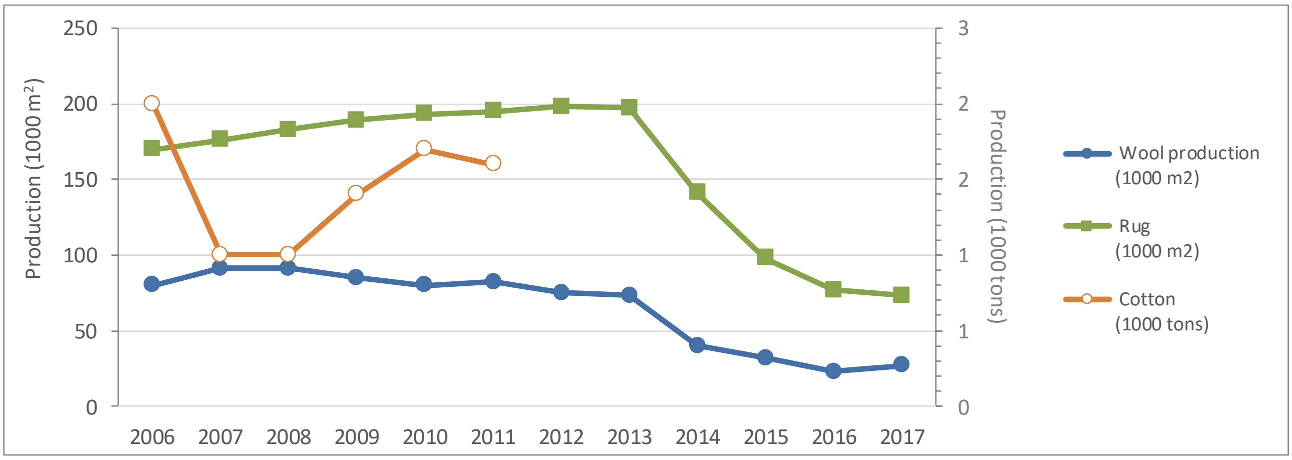


Figure 79 Products of the Textile and Leather Industry in the period 2006 – 2017

Source: NSIA: Afghanistan Statistical yearbook (All years).

3.2.6.12.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 106 Planned improvements for IPCC sub-category 1.A.2.l Textile and Leather

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.l	Analysis of Textile and Leather industry • annual quantity of product produced • annual electricity consumption	AD	Accuracy Transparency Completeness	high

3.2.6.13 Other (IPCC category 1.A.2.m)

3.2.6.13.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.m	✓	✓	IE	NE	NO	IE	✓	✓	IE	NE	NO	IE	✓	✓	IE	NE	NO	IE
Key Category	LA 1990, 2017 TA	LA 1990, 2017 TA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment

Use of notation key

IE	1.A.2.m gaseous	Natural gas is used in one power plant which is mainly serving the Northern Fertilizer Power Plant (NFPP). Therefore, these activity data and emissions are included in IPCC sub-category 1.A.2.c *Chemicals*.
IE	1.A.2.m biomass	The amount of fuel consumption is included in 1.A.4.
NE	1.A.2.m Other fossil fuel	The amount of fuel consumption is not known/available.

This section describes GHG emissions resulting from fuel combustion activities in manufacturing industries and construction which originate from electricity and heat production plants (autoproducer) but which could not be classified under any of the other subcategories from 1.A.2 subcategory.

The national energy statistics currently do not provide information regarding the use of fuels in the different IPCC subcategories. Therefore, all emission except those for IPCC subcategory 1.A.2.c *Chemicals* are reported under IPCC subcategory 1.A.2.m *Other*:

- Iron and Steel (IPCC subcategory 1.A.2.a)
- Non-Ferrous Metals (IPCC subcategory 1.A.2.b)
- Pulp, Paper and Print (IPCC subcategory 1.A.2.d)
- Food Processing, Beverages and Tobacco (IPCC subcategory 1.A.2.e)
- Non-Metallic Minerals (IPCC subcategory 1.A.2.f)
- Mining (excluding fuels) and Quarrying (IPCC subcategory 1.A.2.i)
- Wood and wood products (IPCC subcategory 1.A.2.j)
- Construction (IPCC subcategory 1.A.2.k)
- Textile and Leather (IPCC subcategory 1.A.2.l)

Energy used for transport by industry is reported but under IPCC category 1.A.3 Transport. GHG emissions arising from off-road and other mobile machinery in industry is also reported under IPCC category 1.A.3 Transport as there is no split in energy statistics.

An overview of the GHG emission from fuel combustion in IPCC sub-category 1.A.2.m *Other* is provided in the following figure and table. The share in total GHG emissions from sector 1.A.1.a is 1.6% for the year 1990, 0.3% for the year 2005, and 13.3% for the year 2017. In the period 1990 to 2017 GHG emissions from sub-category 1.A.2.m decreased by 1860.4% from 243.66 Gg CO_2 eq in 1990 to 177.05 Gg CO_2 eq in 2017. In the period 2005 to 2017 GHG emissions from sub-category 1.A.2.m decreased by -17.6%. With the increased availability of hard coal since 2007 all industrial branches, especially the energy intensive cement and lime industry were able to produce more. But also, the diversification of industry like iron scrap recycling led to increased fuel consumption. The annual fluctuations in fuel consumption in this sector is also due to the Afghan Civil War and War in Afghanistan.

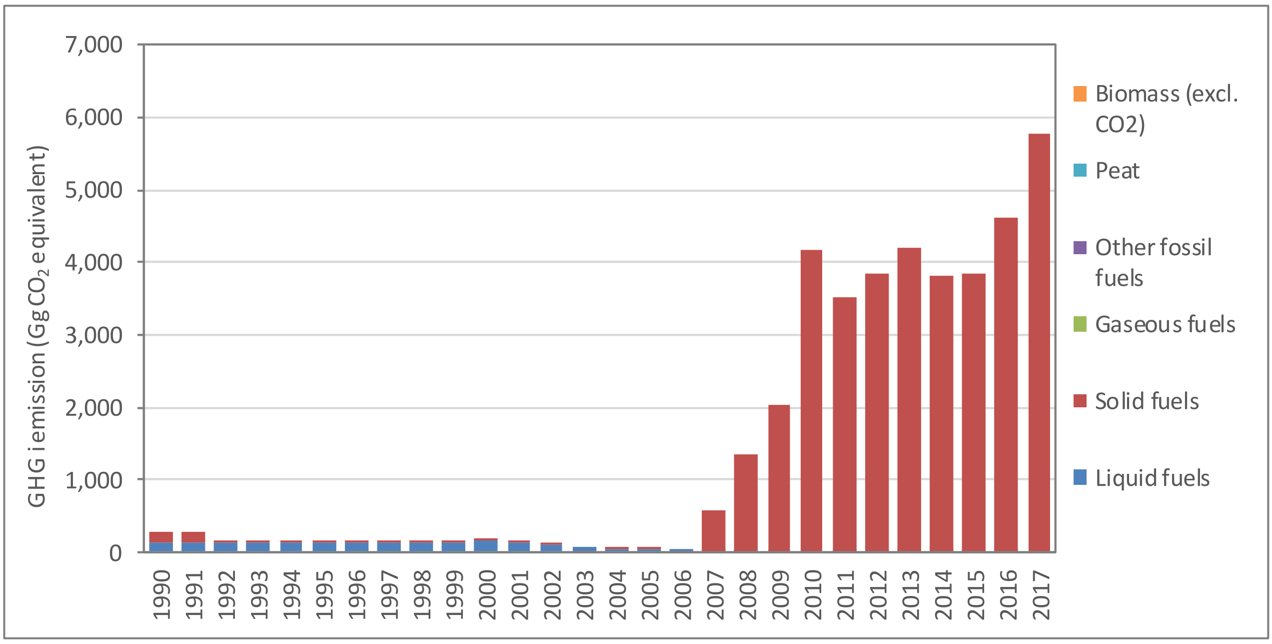


Figure 80 Emissions from IPCC sub-category 1.A.2.m Other

Table 107 Emissions from IPCC sub-category 1.A.2.m Other

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	295.13	293.48	0.57	1.09	NO
1991	266.83	265.38	0.49	0.96	NO
1992	145.28	144.70	0.18	0.40	NO
1993	142.70	142.15	0.17	0.38	NO
1994	143.33	142.78	0.17	0.38	NO
1995	140.75	140.22	0.16	0.37	NO
1996	135.61	135.11	0.15	0.34	NO
1997	136.23	135.75	0.15	0.34	NO
1998	136.23	135.75	0.15	0.34	NO
1999	136.86	136.38	0.14	0.33	NO
2000	159.24	158.68	0.16	0.39	NO
2001	143.33	142.78	0.17	0.38	NO
2002	98.49	98.14	0.10	0.24	NO
2003	54.28	54.14	0.03	0.10	NO
2004	39.07	38.89	0.06	0.12	NO
2005	67.04	66.85	0.06	0.13	NO
2006	20.05	20.58	NO	NO	NO

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$
2007	584.54	581.18	1.21	2.15	NO
2008	1,350.42	1,341.99	3.03	5.40	NO
2009	2,045.77	2,033.02	4.59	8.16	NO
2010	4,187.77	4,161.36	9.50	16.91	NO
2011	3,519.56	3,498.04	7.75	13.77	NO
2012	3,833.72	3,809.91	8.57	15.24	NO
2013	4,206.04	4,179.50	9.55	16.99	NO
2014	3,802.59	3,779.00	8.49	15.10	NO
2015	3,861.13	3,837.01	8.68	15.44	NO
2016	4,619.86	4,590.18	10.67	19.00	NO
2017	5,785.71	5,747.51	13.73	24.47	NO
Trend 1990 - 2017	1,860%	1,858%	2,319%	2141%	-
Trend 2005 - 2017	8,530%	6,766%	17,293%	14,802%	-
Trend 2016 - 2017	25%	25%	29%	29%	-

3.2.6.13.2 Methodological issues

3.2.6.13.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[73] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

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

Where:

Emissions $_{GHG,\ fuel}$ = emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$ = amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$ = default emission factor of a given GHG by type of fuel (kg gas/TJ)
For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG = CO_2, CH_4, N_2O

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{\mathbf{GHG,\,fuel}}}$$

[73] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

For estimating the air pollutants emissions (NO_x, CO, NMVOC, SO_2) the Tier 1 approach[74] of the EMEP/EEA air pollutant emission inventory guidebook 2016 has been applied:

Equation: Air pollutant emissions from stationary combustion

$$Emissions_{pollutant} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{pollutant,\ fuel}$$

Where:

$Emissions_{pollutant}$	= emissions of a given pollutant by type of fuel (kg pollutant)
$Fuel\ consumption_{fuel}$	= amount of fuel combusted (TJ)
$Emission\ factor_{pollutant,\ fuel}$	= default emission factor of a given pollutant by type of fuel ($g_{pollutant}$/GJ).
Pollutant	= NOx, CO, NMVOC, SO_2

3.2.6.13.2.2 Choice of activity data

The following fuels are used for electricity production:

Gaseous fuels	Natural gas
Biomass	Fuel wood
Solid fuels:	Hard coal • Coking coal • Other bituminous coal Gas Coke
Liquid fuels:	Gas/Diesel Oil
Other fossil fuel	Waste

Natural gas is used in the power plant which is mainly serving the Northern Fertilizer Power Plant (NFPP) in Mazar-e-Sharif. The Northern Fertilizer Power Plant (NFPP) is an autoproducer which is also provides electricity to the public. As the principal activity is fertilizer production, the activity data and emissions are included in IPCC sub-category 1.A.2.c *Chemicals* and IPCC sub-category *2.B.1 Ammonia Production.*

The amount of fuel consumption in the manufacturing industries and construction is not well known. Therefore, the whole amount of fuel wood is included in 1.A.4.

The amount of waste like tires, waste oil, plastics or other fossil-based waste used for fuel consumption is not known. However, in general, it is forbidden to burn waste it, but it happens.

The fuel consumption used for estimating the GHG and non-GHG emissions are taken for the years

- 2006 - 2013 from the national energy statistics prepared by Ministry of Energy & Water (MEW) and National Statistics and Information Authority (NSIA); but this data does only provide the national production, import and/or export. The final supply and the split to the different industries are taken from UNSD statistics.
- 1990 – 2005 from the UN Statistics Division (UNSD) - Energy Statistics Section.

The amount of hard coal is divided in Coking coal (50%) and Other bituminous coal (50%) as both types of hard coal are produced. This division is done in order to avoid under- or overestimation.

With the increased availability of national hard coal and the import of gas coal since 2007 all industrial branches, especially the energy intensive cement and lime industry were able to produce more. But also, the

[74] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, 1.A.2 Manufacturing industries and construction (combustion), sub-chapter 3.2.1 Tier 1 default approach.

diversification of industry like iron scrap recycling led to increased fuel consumption. The annual fluctuations in fuel consumption in this sector is also due to the Afghan Civil War (1989–92, 1996–2001) and War in Afghanistan (2001–present).

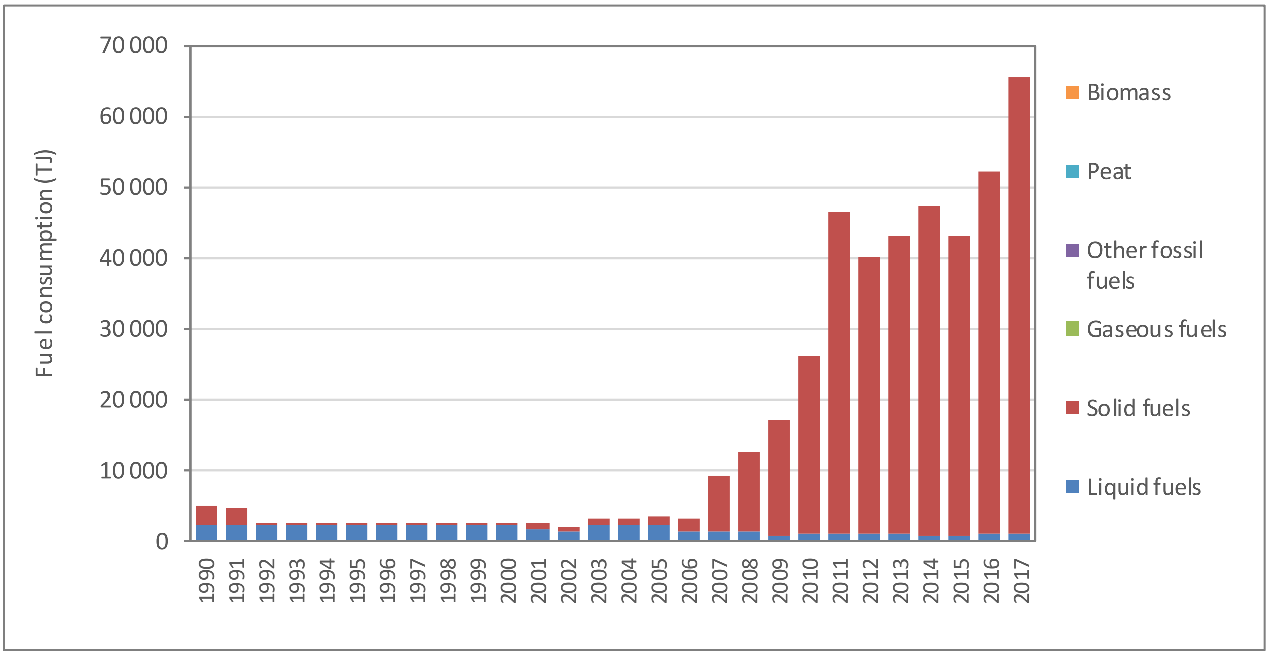


Figure 81 Activity data for IPCC sub-category 1.A.2.m Other

Table 108 Activity data for IPCC sub-category 1.A.2.m Other

Activity data 1.A.2.m	Total fuels (incl. biomass)	Liquid fuels	Solid fuels				Gaseous fuels	Other fossil fuels	Peat	Biomass
			Total	Coking coal	Other Bituminous Coal	Gas coke				
	TJ									
1990	4 985	2 150	2 835	1 481	1 355	NO	IE	NE	NO	NO
1991	4 688	2 150	2 538	1 325	1 213	NO	IE	NE	NO	NO
1992	2 366	2 150	216	113	103	NO	IE	NE	NO	NO
1993	2 339	2 150	189	99	90	NO	IE	NE	NO	NO
1994	2 312	2 150	162	85	77	NO	IE	NE	NO	NO
1995	2 285	2 150	135	71	65	NO	IE	NE	NO	NO
1996	2 231	2 150	81	42	39	NO	IE	NE	NO	NO
1997	2 204	2 150	54	28	26	NO	IE	NE	NO	NO
1998	2 204	2 150	54	28	26	NO	IE	NE	NO	NO
1999	2 177	2 150	27	14	13	NO	IE	NE	NO	NO
2000	2 177	2 150	27	14	13	NO	IE	NE	NO	NO
2001	2 422	1 720	702	367	335	NO	IE	NE	NO	NO
2002	1 857	1 290	567	296	271	NO	IE	NE	NO	NO
2003	3 095	2 150	945	494	452	NO	IE	NE	NO	NO
2004	3 068	2 150	918	479	439	NO	IE	NE	NO	NO

Activity data 1.A.2.m	Total fuels (incl. biomass)	Liquid fuels	Solid fuels				Gaseous fuels	Other fossil fuels	Peat	Biomass
			Total	Coking coal	Other Bituminous Coal	Gas coke				
	TJ									
2005	3 267	2 150	1 117	465	426	226	IE	NE	NO	NO
2006	3 025	1 290	1 735	494	452	790	IE	NE	NO	NO
2007	9 064	1 290	7 774	3 426	3 135	1 213	IE	NE	NO	NO
2008	12 546	1 290	11 256	4 891	4 475	1 889	IE	NE	NO	NO
2009	17 165	645	16 520	7 051	6 451	3 017	IE	NE	NO	NO
2010	26 213	860	25 353	10 221	9 351	5 781	IE	NE	NO	NO
2011	46 590	860	45 730	20 862	19 087	5 781	IE	NE	NO	NO
2012	40 118	860	39 258	17 483	15 995	5 781	IE	NE	NO	NO
2013	43 225	1 075	42 150	18 993	17 376	5 781	IE	NE	NO	NO
2014	47 396	645	46 751	21 395	19 574	5 781	IE	NE	NO	NO
2015	43 137	645	42 492	19 244	17 606	5 643	IE	NE	NO	NO
2016	52 354	860	51 494	23 945	21 907	5 643	IE	NE	NO	NO
2017	65 692	881	64 811	30 899	28 269	5 643	IE	NE	NO	NO
Trend										
1990 - 2017	*1218%*	*-59%*	*2186%*	*1987%*	*1987%*	*NA*	-	-	-	-
2005 - 2017	*1911%*	*-59%*	*5704%*	*5046%*	*5046%*	*2401%*	-	-	-	-
1990 - 2017	*25%*	*2%*	*26%*	*29.0%*	*29.0%*	*0.0%*	-	-	-	-

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic metres. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.2.m *Other*.

Table 109 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.2.m Other

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Gas/Diesel Oil	liquid	43.0	D	**2006 IPCC Guidelines, Vol. 2, Chap. 1, Table 1.2** Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
Coking coal	solid	28.2	D	
Other bituminous coal	solid	25.8	D	
Gas Coke	solid	28.2	D	
Note:				
D Default	CS Country specific	PS Plant specific		

3.2.6.13.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 110 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2.m Other

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.3** Default emission factors for manufacturing industries and construction (page 2.18)
Coking coal	solid	94 600	D	10	D	1.5	D	
Other bituminous coal	solid	94 600		10	D	1.5	D	
Gas Coke	solid	107 000	D	1	D	0.1	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

Default emission factors for air pollutant were taken from the EMEP/EEA air pollutant emission inventory Guidebook 2016 and are presented in the following table.

Table 111 Non-GHG Emission factor for IPCC sub-category 1.A.2.m Other

Fuel	Fuel type	NOx (g/GJ)		CO (g/GJ)		NMVOC (g/GJ)		SO_2 (g/GJ)		Source
		EF	type	EF	type	EF	type	EF	type	EMEP/EEA Guidebook 2016, Part B, Vol 1 - 1A, chap. 1.A.2
Gas/Diesel Oil	liquid	513	D	66	D	25	D	47	D	**Table 3-4** Tier 1 emission factors for 1.A.2 combustion in industry using liquid fuels (page. 16)
Coking coal	solid	173		931		88.8		900		**Table 3-2** Tier 1 emission factors for 1.A.2 combustion in industry using solid fuels (page. 15)
Other bituminous coal	solid									
Gas Coke	solid									

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.6.13.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.2.m *Other* are presented in the following table.

Table 112 Uncertainty for IPCC sub-category 1.A.2.m Other.

Uncertainty	Liquid fuels			Gaseous Fuels			Reference
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	2006 IPCC GL, Vol. 2, Chap. 2 (2.4.2)
Activity data (AD)	10%	10%	10%	10%	10%	10%	Table 2.15
Emission factor (EF)	7%			3%			Table 2.13
		100%			100%		Table 2.12
			10%			10%	Table 2.14
Combined Uncertainty (U)	12%	100%	22%	10%	100%	22%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.2.6.13.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.13.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category 1.A.2.m *Other*.

Table 113 Recalculations done since SNC in IPCC sub-category 1.A.2.m Other

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.2.m	Fuel consumption data (activity data) was revised due to • revised activity data • consideration of imported fuels (reported by importers)(UNSD)	AD	Accuracy
1.A.2.m	Reallocation of fuel consumption (natural gas, solid fuels) to relevant subcategories – 1.A.2	AD	Transparency Comparability
1.A.2.m	use of default NCV of 2006 IPCC Guidelines	AD	Comparability
1.A.2.m	use of default EF of 2006 IPCC Guidelines	EF	Comparability
1.A.2.m	application of 2006 IPCC Guidelines	method	Comparability

3.2.6.13.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 114 Planned improvements for IPCC sub-category 1.A.2.m Other

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2	Survey on fuel used (solid, natural gas, liquid fuels, other fossil fuels, etc.) in all power and heat plants (autoproducer) per industry branch: • annual amount of fuel consumption by fuel type for combustion in different industries • annual capacity annual production / output	AD	Completeness	high
1.A.2	Cross-check of national and international data sources and feedback to UNSD	AD	Completeness	medium
1.A.2	Time-series of fuel consumption ⇒ missing values in some years	AD	Consistency Completeness	high
1.A.2	Cross-check of national and international data sources and feedback to UNSD	AD	Consistency Transparency	medium
1.A.2	Country specific Net Caloric Value (NCV) for imported fuels: diesel and residual fuel ⇒ conversion from mass unit to energy unit (unit EF is kg /TJ)	AD EF	Accuracy Transparency	medium
1.A.2	Carbon content (%) of gas/diesel oil, residual fuel oil, natural gas etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF_{CO2}** [t/TJ] = (C [%] • 44 • Ox) / (NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	medium
1.A.2	Sulphur content in used fuel for preparing country specific emission factor (CS EF) ⇒ **CS EF_{SO2}** [g/GJ] = (S [%] • 20000) / (NCV [GJ/t])	EF non-GHG	Accuracy Transparency	medium
1.A.2	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF non-GHG	Accuracy Transparency	medium
1.A.2	Data obtained from measurements made on the emission of air polluters (NON-GHG inventory) • Determination of the temperature in waste gases [°C]; • Determination of the static pressure and the dynamic pressure [kPa]; • Determination of the flow rate [m/s]; • Determination of volume flow rate [m^3/h and Nm^3/h]; • Determination of the concentration of CO, SO_2, NOx in the exhaust gases [mg/Nm^3]; and Gravimetric extraction of solid particles (TSP) from gases and determination by applying a gravimetric method (mg/Nm^3).	EF non-GHG	Accuracy Transparency	medium

3.2.7 Transport (IPCC category 1.A.3)

This section describes GHG emissions resulting from fuel combustion in transport sector, which originate from the following subcategories.

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
1.A.3.a	Civil Aviation						
1.A.3.a.i	International Aviation (International Bunkers)	✓	-	✓	-	✓	-
1.A.3.a.ii	Domestic Aviation	✓	LA 1990, TA	✓	-	✓	-
1.A.3.b	Road Transportation						
1.A.3.b.i	Cars	✓	LA 1990, LA 2017, TA	✓	-	✓	-
1.A.3.b.ii	Light-duty trucks	✓	LA 2017, TA	✓	-	✓	-
1.A.3.b.iii	Heavy-duty trucks and buses	✓	LA 1990, LA 2017, TA	✓	-	✓	-
1.A.3.b.iv	Motorcycles	✓	LA 2017, TA	✓	-	✓	-
1.A.3.b.v	Evaporative emissions from vehicles	NA	-	NA	-	NA	-
1.A.3.b.vi	Urea-based catalysts	NE	-	NA	-	NA	-
1.A.3.c	Railways	IE	-	IE	-	IE	-
1.A.3.d	Water-borne Navigation						
1.A.3.d.i	International water-borne navigation (International bunkers)	IE	-	IE	-	IE	-
1.A.3.d.ii	Domestic Water-borne Navigation	IE	-	IE	-	IE	-
1.A.3.e	Other Transportation						
1.A.3.e.i	Pipeline Transport	NE	-	NE	-	NE	-
1.A.3.e.ii	Off-road / Other	IE	-	IE	-	IE	-

A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment

Use of notation key

IE	1.A.3.c Railways	Emissions are included in road transport as the diesel consumption is currently not split to different transport modes.
IE	1.A.3.d Water-borne Navigation	Emissions are included in road transport as the diesel consumption is currently not split to different transport modes.
IE	1.A.3.e.ii Off-road / Other	Emissions are included in road transport as the diesel consumption is currently not split to different transport modes.

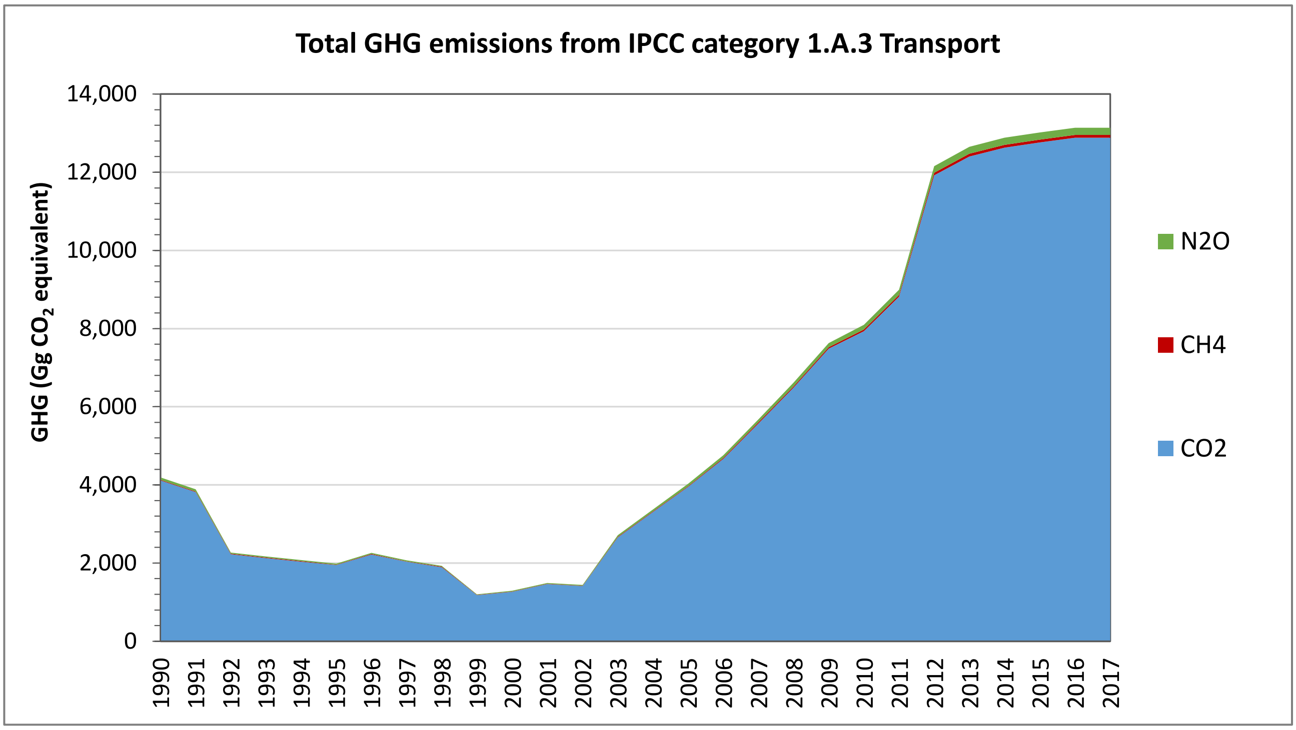


Figure 82 GHG Emissions by gas from IPCC category 1.A.3 Transport

In the IPCC category 1.A.3 *Transport*, emissions originating from fuel combustion activities in *civil aviation*, in the *road transport*, railways, navigation and *Other transport* are considered.

Emissions from the IPCC category 1.A.3 *Transport* are a main source of GHGs in Afghanistan:

- in 1990 about 23.2% of the total national GHG emissions and 79.3% of total CO_2 emissions arose from the *transport*, whereas CH_4 and N_2O emissions only make up about 0.2% and 1.8%, respectively.
- in 2005 about 17.9% of the total national GHG emissions and 82.8% of total CO_2 emissions arose from the *transport*, whereas CH_4 and N_2O emissions only make up about 0.1% and 1.1%, respectively.
- in 2017 about 30.2% of the total national GHG emissions and 61.5% of total CO_2 emissions arose from the *transport*, whereas CH_4 and N_2O emissions only make up about 0.4% and 3.0%, respectively.

An overview of the GHG emissions from *Transport* (IPCC sub-category 1.A.3) are provided in the following figure and tables.

Table 115 GHG Emissions by gas from IPCC category 1.A.3 Transport

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg	Gg	Gg
1990	4,190.11	4,114.52	15.98	59.61	0.64	0.20	NO
1991	3,888.31	3,818.13	14.85	55.34	0.59	0.19	NO
1992	2,268.88	2,224.56	13.29	31.03	0.53	0.10	NO
1993	2,172.52	2,129.97	12.91	29.64	0.52	0.10	NO
1994	2,076.53	2,035.84	12.41	28.28	0.50	0.09	NO
1995	1,986.77	1,947.69	12.05	27.04	0.48	0.09	NO
1996	2,264.41	2,219.24	14.05	31.12	0.56	0.10	NO
1997	2,072.57	2,031.14	13.00	28.43	0.52	0.10	NO
1998	1,932.07	1,893.40	12.19	26.48	0.49	0.09	NO
1999	1,200.97	1,181.08	2.92	16.97	0.12	0.06	NO
2000	1,289.07	1,266.88	4.01	18.18	0.16	0.06	NO
2001	1,490.10	1,463.53	5.45	21.12	0.22	0.07	NO
2002	1,439.17	1,414.41	4.04	20.72	0.16	0.07	NO
2003	2,710.72	2,654.69	17.98	38.05	0.72	0.13	NO
2004	3,370.92	3,308.17	13.83	48.93	0.55	0.16	NO
2005	4,027.38	3,951.73	17.15	58.50	0.69	0.20	NO
2006	4,755.08	4,664.93	20.99	69.16	0.84	0.23	NO
2007	5,679.96	5,571.22	26.66	82.08	1.07	0.28	NO
2008	6,614.39	6,486.98	32.32	95.09	1.29	0.32	NO
2009	7,631.50	7,484.71	38.00	108.78	1.52	0.37	NO
2010	8,094.18	7,935.87	41.71	116.60	1.67	0.39	NO
2011	8,991.74	8,817.20	45.34	129.20	1.81	0.43	NO
2012	12,156.56	11,919.48	66.35	170.72	2.65	0.57	NO
2013	12,649.52	12,402.97	68.72	177.83	2.75	0.60	NO
2014	12,880.92	12,630.02	69.70	181.20	2.79	0.61	NO
2015	13,015.30	12,761.96	70.29	183.05	2.81	0.61	NO
2016	13,136.61	12,881.00	70.76	184.86	2.83	0.62	NO
2017	13,136.61	12,881.00	70.76	184.86	2.83	0.62	NO
Trend							
1990 - 2017	213.5%	213.1%	342.77%	210.11%	342.77%	210.11%	-
2005 - 2017	226.2%	226.0%	312.67%	216.00%	312.67%	216.00%	-
2012 - 2017	8.1%	8.1%	6.64%	8.28%	6.64%	8.28%	-
2016 - 2017	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%	-

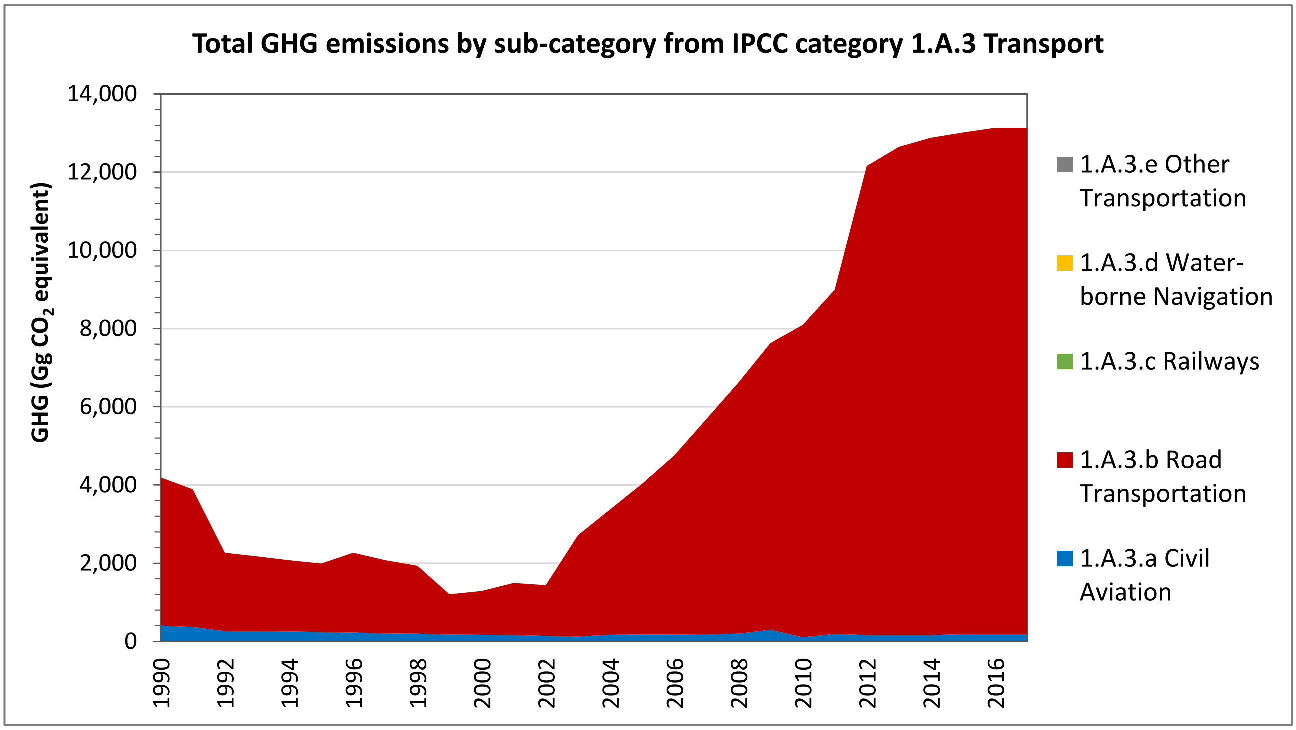


Figure 83 GHG Emissions by sub-category from IPCC category 1.A.3 Transport

The most important sources of GHGs in the IPCC category 1.A.3 *Transport* is *Road Transport* and *Civil aviation*. With regards to CO_2 emission, the source *Road Transport* was the primary source.

In the period 1990 to 2017 GHG emissions from the IPCC category 1.A.3 *Transport* increased by 213.5% from 4,190.11 Gg CO_2 eq in 1990 to 13,136.61 Gg CO_2 eq in 2017, which is caused by enormous increasing emissions from fuel combustion in *Road transport* (IPCC subcategory 1.A.3.b).

In the period 2005 to 2017 GHG emissions from the IPCC category 1.A.3 *Transport* increased by 226.2% from 4,027.38 Gg CO_2 eq in 2005 to 13,136.61 Gg CO_2 eq in 2017, which is again caused by increasing emissions from fuel combustion in *Road transport* (IPCC subcategory 1.A.3.a).

In the period 2016 to 2017 GHG emissions from the IPCC category 1.A.3 *Transport* remain stable.

An overview of the GHG emissions from *Transport* (IPCC sub-category 1.A.3) are provided in the following figure and tables.

Table 116 GHG Emissions by sub-category from IPCC category 1.A.3 Transport

GHG emissions	1.A.3 Transport	1.A.3.a Civil Aviation	1.A.3.b Road Transportation	1.A.3.c Railways	1.A.3.d Water-borne Navigation	1.A.3.e Other Transportation
Years	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	4,190.11	400.68	3,789.43	IE	IE	NE
1991	3,888.31	368.88	3,519.43	IE	IE	NE
1992	2,268.88	263.94	2,004.94	IE	IE	NE
1993	2,172.52	257.58	1,914.94	IE	IE	NE
1994	2,076.53	251.22	1,825.31	IE	IE	NE
1995	1,986.77	238.50	1,748.27	IE	IE	NE
1996	2,264.41	222.60	2,041.81	IE	IE	NE
1997	2,072.57	206.70	1,865.88	IE	IE	NE
1998	1,932.07	193.98	1,738.09	IE	IE	NE
1999	1,200.97	174.90	1,026.07	IE	IE	NE
2000	1,289.07	168.54	1,120.53	IE	IE	NE
2001	1,490.10	159.00	1,331.10	IE	IE	NE
2002	1,439.17	143.10	1,296.07	IE	IE	NE
2003	2,710.72	127.20	2,583.52	IE	IE	NE
2004	3,370.92	165.36	3,205.56	IE	IE	NE
2005	4,027.38	174.90	3,852.48	IE	IE	NE
2006	4,755.08	174.90	4,580.18	IE	IE	NE
2007	5,679.96	181.26	5,498.70	IE	IE	NE
2008	6,614.39	197.16	6,417.23	IE	IE	NE
2009	7,631.50	295.74	7,335.76	IE	IE	NE
2010	8,094.18	101.76	7,992.42	IE	IE	NE
2011	8,991.74	190.80	8,800.94	IE	IE	NE
2012	12,156.56	162.18	11,994.38	IE	IE	NE
2013	12,649.52	162.18	12,487.34	IE	IE	NE
2014	12,880.92	163.77	12,717.15	IE	IE	NE
2015	13,015.30	179.67	12,835.63	IE	IE	NE
2016	13,136.61	179.35	12,957.26	IE	IE	NE
2017	13,136.61	179.35	12,957.26	IE	IE	NE
Trend						
1990 - 2017	*213.5%*	*-55.2%*	*241.9%*	*NA*	*NA*	*NA*
2005 - 2017	*226.2%*	*2.5%*	*236.3%*	*NA*	*NA*	*NA*
2012 - 2017	*8.1%*	*10.6%*	*8.0%*	*NA*	*NA*	*NA*
2016 - 2017	*0.0%*	*0.0%*	*0.0%*	*NA*	*NA*	*NA*

Table 117 CO_2 Emissions by sub-category from IPCC category 1.A.3 Transport

CO_2 emissions	1.A.3	1.A.3.a	1.A.3.b	1.A.3.c	1.A.3.d	1.A.3.e
	Transport	Civil Aviation	Road Transportation	Railways	Water-borne Navigation	Other Transportation
Years	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	4,114.52	397.30	3,717.22	IE	IE	NE
1991	3,818.13	365.77	3,452.36	IE	IE	NE
1992	2,224.56	261.71	1,962.85	IE	IE	NE
1993	2,129.97	255.41	1,874.56	IE	IE	NE
1994	2,035.84	249.10	1,786.74	IE	IE	NE
1995	1,947.69	236.49	1,711.20	IE	IE	NE
1996	2,219.24	220.72	1,998.52	IE	IE	NE
1997	2,031.14	204.95	1,826.18	IE	IE	NE
1998	1,893.40	192.34	1,701.06	IE	IE	NE
1999	1,181.08	173.42	1,007.66	IE	IE	NE
2000	1,266.88	167.12	1,099.76	IE	IE	NE
2001	1,463.53	157.66	1,305.87	IE	IE	NE
2002	1,414.41	141.89	1,272.52	IE	IE	NE
2003	2,654.69	126.13	2,528.56	IE	IE	NE
2004	3,308.17	163.96	3,144.21	IE	IE	NE
2005	3,951.73	173.42	3,778.31	IE	IE	NE
2006	4,664.93	173.42	4,491.50	IE	IE	NE
2007	5,571.22	179.73	5,391.49	IE	IE	NE
2008	6,486.98	195.50	6,291.48	IE	IE	NE
2009	7,484.71	293.24	7,191.47	IE	IE	NE
2010	7,935.87	100.90	7,834.97	IE	IE	NE
2011	8,817.20	189.19	8,628.02	IE	IE	NE
2012	11,919.48	160.81	11,758.67	IE	IE	NE
2013	12,402.97	160.81	12,242.16	IE	IE	NE
2014	12,630.02	162.39	12,467.64	IE	IE	NE
2015	12,761.96	178.15	12,583.81	IE	IE	NE
2016	12,881.00	177.84	12,703.16	IE	IE	NE
2017	12,881.00	177.84	12,703.16	IE	IE	NE
Trend						
1990 - 2017	*213.1%*	*-55.2%*	*241.7%*	*NA*	*NA*	*NA*
2005 - 2017	*226.0%*	*2.5%*	*236.2%*	*NA*	*NA*	*NA*
2012 - 2017	*8.1%*	*10.6%*	*8.0%*	*NA*	*NA*	*NA*
2016 - 2017	*0.0%*	*0.0%*	*0.0%*	*NA*	*NA*	*NA*

Table 118 CH_4 Emissions by sub-category from IPCC category 1.A.3 Transport

CH_4 emissions	1.A.3	1.A.3.a	1.A.3.b	1.A.3.c	1.A.3.d	1.A.3.e
	Transport	Civil Aviation	Road Transportation	Railways	Water-borne Navigation	Other Transportation
Years	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	0.64	0.00	0.64	IE	IE	NE
1991	0.59	0.00	0.59	IE	IE	NE
1992	0.53	0.00	0.53	IE	IE	NE
1993	0.52	0.00	0.51	IE	IE	NE
1994	0.50	0.00	0.49	IE	IE	NE
1995	0.48	0.00	0.48	IE	IE	NE
1996	0.56	0.00	0.56	IE	IE	NE
1997	0.52	0.00	0.52	IE	IE	NE
1998	0.49	0.00	0.49	IE	IE	NE
1999	0.12	0.00	0.12	IE	IE	NE
2000	0.16	0.00	0.16	IE	IE	NE
2001	0.22	0.00	0.22	IE	IE	NE
2002	0.16	0.00	0.16	IE	IE	NE
2003	0.72	0.00	0.72	IE	IE	NE
2004	0.55	0.00	0.55	IE	IE	NE
2005	0.69	0.00	0.68	IE	IE	NE
2006	0.84	0.00	0.84	IE	IE	NE
2007	1.07	0.00	1.07	IE	IE	NE
2008	1.29	0.00	1.29	IE	IE	NE
2009	1.52	0.00	1.52	IE	IE	NE
2010	1.67	0.00	1.67	IE	IE	NE
2011	1.81	0.00	1.81	IE	IE	NE
2012	2.65	0.00	2.65	IE	IE	NE
2013	2.75	0.00	2.75	IE	IE	NE
2014	2.79	0.00	2.79	IE	IE	NE
2015	2.81	0.00	2.81	IE	IE	NE
2016	2.83	0.00	2.83	IE	IE	NE
2017	2.83	0.00	2.83	IE	IE	NE
Trend						
1990 - 2017	*342.8%*	*-55.2%*	*344.5%*	*NA*	*NA*	*NA*
2005 - 2017	*312.7%*	*2.5%*	*313.2%*	*NA*	*NA*	*NA*
2012 - 2017	*6.6%*	*10.6%*	*6.6%*	*NA*	*NA*	*NA*
2016 - 2017	*0.0%*	*0.0%*	*0.0%*	*NA*	*NA*	*NA*

Table 119 N_2O Emissions by sub-category from IPCC category 1.A.3 Transport

N_2O emissions	1.A.3	1.A.3.a	1.A.3.b	1.A.3.c	1.A.3.d	1.A.3.e
	Transport	Civil Aviation	Road Transportation	Railways	Water-borne Navigation	Other Transportation
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	0.20	0.01	0.19	IE	IE	NE
1991	0.19	0.01	0.18	IE	IE	NE
1992	0.10	0.01	0.10	IE	IE	NE
1993	0.10	0.01	0.09	IE	IE	NE
1994	0.09	0.01	0.09	IE	IE	NE
1995	0.09	0.01	0.08	IE	IE	NE
1996	0.10	0.01	0.10	IE	IE	NE
1997	0.10	0.01	0.09	IE	IE	NE
1998	0.09	0.01	0.08	IE	IE	NE
1999	0.06	0.00	0.05	IE	IE	NE
2000	0.06	0.00	0.06	IE	IE	NE
2001	0.07	0.00	0.07	IE	IE	NE
2002	0.07	0.00	0.07	IE	IE	NE
2003	0.13	0.00	0.12	IE	IE	NE
2004	0.16	0.00	0.16	IE	IE	NE
2005	0.20	0.00	0.19	IE	IE	NE
2006	0.23	0.00	0.23	IE	IE	NE
2007	0.28	0.01	0.27	IE	IE	NE
2008	0.32	0.01	0.31	IE	IE	NE
2009	0.37	0.01	0.36	IE	IE	NE
2010	0.39	0.00	0.39	IE	IE	NE
2011	0.43	0.01	0.43	IE	IE	NE
2012	0.57	0.00	0.57	IE	IE	NE
2013	0.60	0.00	0.59	IE	IE	NE
2014	0.61	0.00	0.60	IE	IE	NE
2015	0.61	0.00	0.61	IE	IE	NE
2016	0.62	0.00	0.62	IE	IE	NE
2017	0.62	0.00	0.62	IE	IE	NE
Trend						
1990 - 2017	*210.1%*	*-55.2%*	*225.7%*	*NA*	*NA*	*NA*
2005 - 2017	*216.0%*	*2.5%*	*221.4%*	*NA*	*NA*	*NA*
2012 - 2017	*8.3%*	*10.6%*	*8.3%*	*NA*	*NA*	*NA*
2016 - 2017	*0.0%*	*0.0%*	*0.0%*	*NA*	*NA*	*NA*

3.2.7.1 Civil Aviation (IPCC category 1.A.3.a)

3.2.7.1.1 Source category description

This section describes GHG emissions resulting from fuel combustion in Civil Aviation (IPCC category 1.A.3.a), which originate from the following subcategories.

- International Aviation (International Bunkers) (1.A.3.a.i)
- Domestic Aviation (IPCC subcategory 1.A.3.a.ii)

According to the 2006 IPCC Guidelines the GHG emissions from domestic aviation are reported separately from international aviation.

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.3.a.i	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO
1.A.3.a.ii	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO
Key Category	LA 1990, TA	yes	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment

GHG emissions from aviation arise from the combustion of jet fuel (jet kerosene and jet gasoline) and aviation gasoline. As presented in the 2006 IPCC Guidelines the emissions that are emitted depend on the

- number and type of aircraft operations;
- types and efficiency of the aircraft engines;
- fuel used;
- length of flight;
- power setting;
- time spent at each stage of flight;
- altitude at which exhaust gases (to a lesser degree).

In the following table the criteria for defining international or domestic aviation is provided.

Table 120 Criteria for defining international or domestic aviation

IPCC code	Description	Journey type between two airports	
		Departs and arrives in same country	Departs from one country and arrives in another
1.A.3.a.i	International Aviation (International Bunkers)	No	**Yes**
1.A.3.a.ii	Domestic Aviation	**Yes**	No

Source: TABLE 3.6.6, 2006 IPCC Guidelines, Vol. 2, Chap. 3.

The country has four international airports, three mayor domestic airports, 18 regional domestic airports and 20 small local airports. Furthermore, Afghanistan has 3 military airports.

The air transport data, which are presented in the next figures, represent and provides an overview of the total (international and domestic) scheduled traffic carried by the air carriers registered in Afghanistan:

- **Air passengers carried** include both domestic and international aircraft passengers of air carriers registered in the country.[75]
- **Air freight** is the volume of freight, express, and diplomatic bags carried on each flight stage (operation of an aircraft from takeoff to its next landing), measured in metric tons times kilometers traveled.[76]
- **Registered carrier departures** worldwide are domestic takeoffs and takeoffs abroad of air carriers registered in the country.[77]

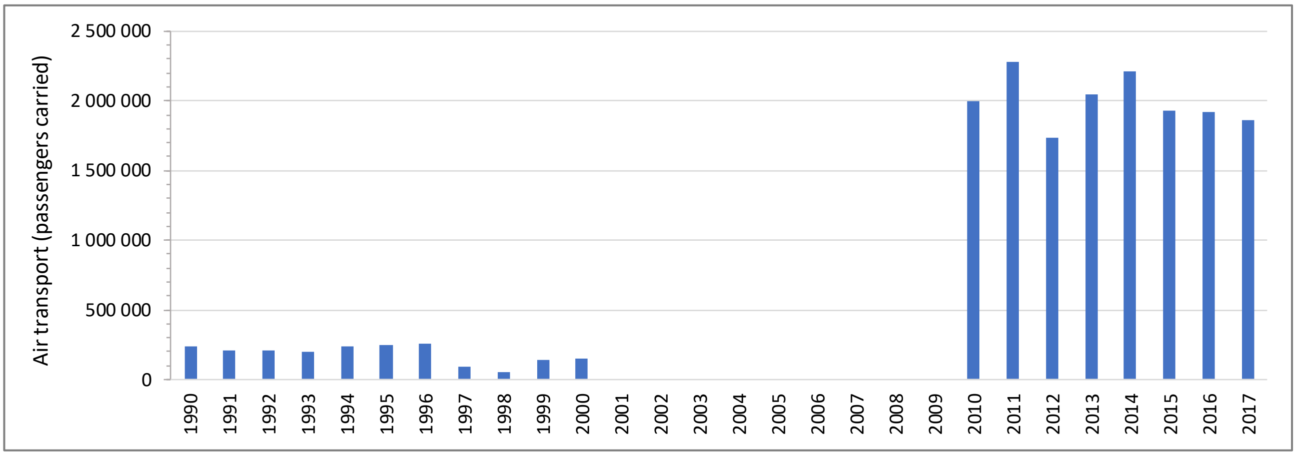


Figure 84 Air transport: Passenger carried

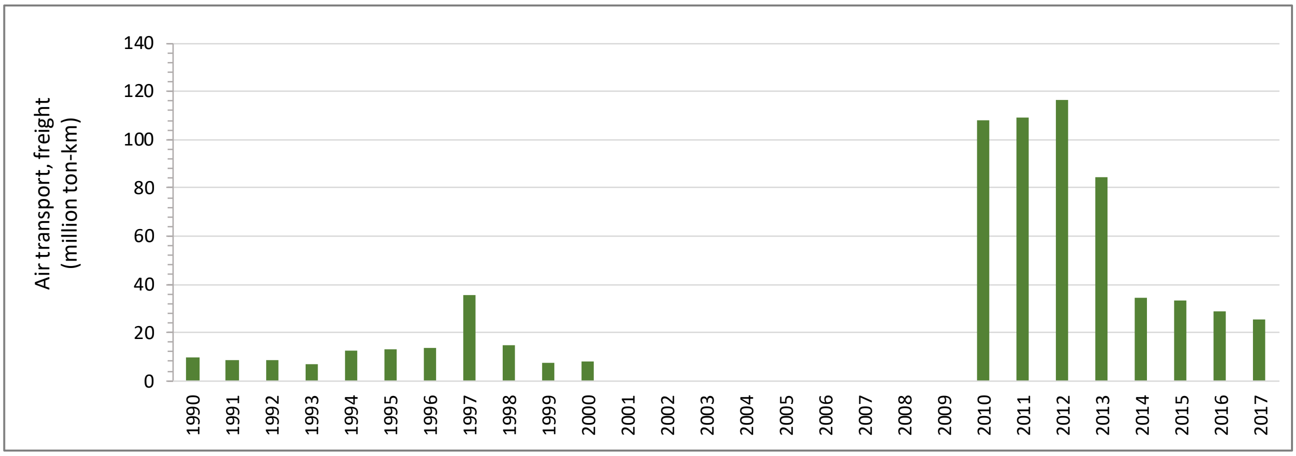


Figure 85 Air transport: freight

[75] OECD - World Development Indicators: Air transport, passengers carried (IS.AIR.PSGR); Available (25. January 2019) on https://databank.worldbank.org/data/reports.aspx?source=2&series=IS.AIR.PSGR

[76] OECD - World Development Indicators: Air transport, freight (million ton-km) (IS.AIR.GOOD.MT.K1); Available (25. January 2019) on https://databank.worldbank.org/data/reports.aspx?source=2&series=IS.AIR.GOOD.MT.K1

[77] Air transport, registered carrier departures worldwide (IS.AIR.DPRT); Available (25. January 2019) on https://databank.worldbank.org/data/reports.aspx?source=2&series=IS.AIR.DPRT

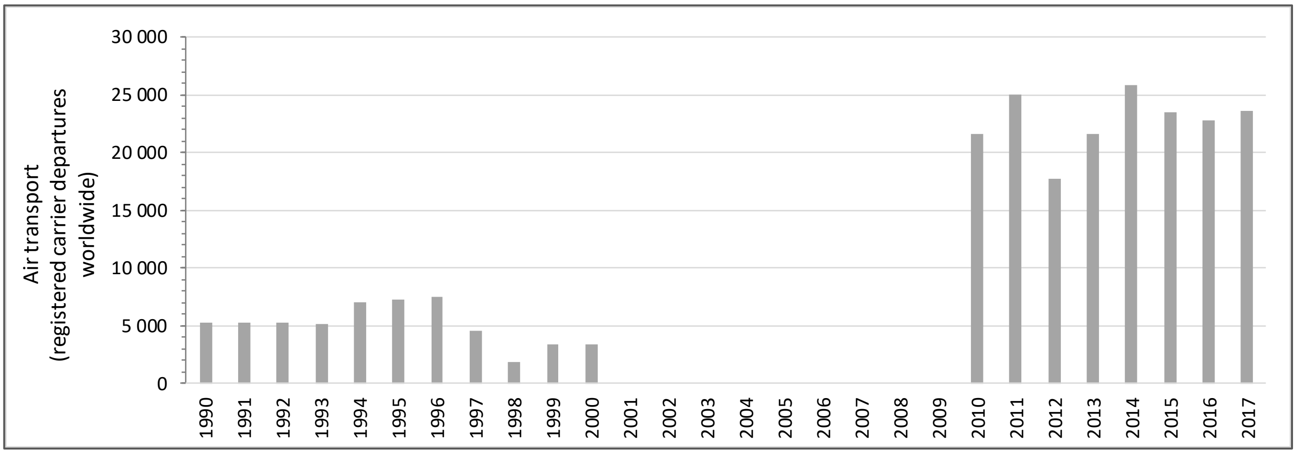


Figure 86 Registered carrier departures worldwide

Emissions from the IPCC sub-category 1.A.3.a *Civil Aviation* are a small source of GHGs in Afghanistan:

- in 1990 about 2.2% of the total national GHG emissions and 7.7% of total CO_2 emissions arose from the *civil aviation - domestic*, whereas CH_4 and N_2O emissions only make up about 0.1% and 0.1%, respectively.
- in 2005 about 0.8%% of the total national GHG emissions and 3.6% of total CO_2 emissions arose from the *civil aviation - domestic*, whereas CH_4 and N_2O emissions only make up less than 0.1% and 0.1%, respectively.
- in 2017 about 0.4% of the total national GHG emissions and 0.8% of total CO_2 emissions arose from the *civil aviation - domestic*, whereas CH_4 and N_2O emissions only make up about 0.4% and 3.0%, respectively.

In the period 1990 to 2017 GHG emissions from the IPCC category 1.A.3.a *Civil Aviation* decreased by -55.2% from 400.68 Gg CO_2 eq in 1990 to 179.35 Gg CO_2 eq in 2017.

In the period 2005 to 2017 GHG emissions from the IPCC category 1.A.3.a *Civil Aviation* increased by 2.5% from 174.90 Gg CO_2 eq in 2005 to 179.35 Gg CO_2 eq in 2017.

In the period 2016 to 2017 GHG emissions from the IPCC category 1.A.3.a *Civil Aviation* remain stable.

The decrease in GHG emissions and the annual fluctuations of the emissions are due to decreased fuel consumption in this sector mainly due to the Afghan Civil War (1989–92, 1996–2001) and War in Afghanistan (2001–present).

An overview of the GHG emissions from IPCC sub-category 1.A.3.a *Civil Aviation* are provided in the following figure and tables.

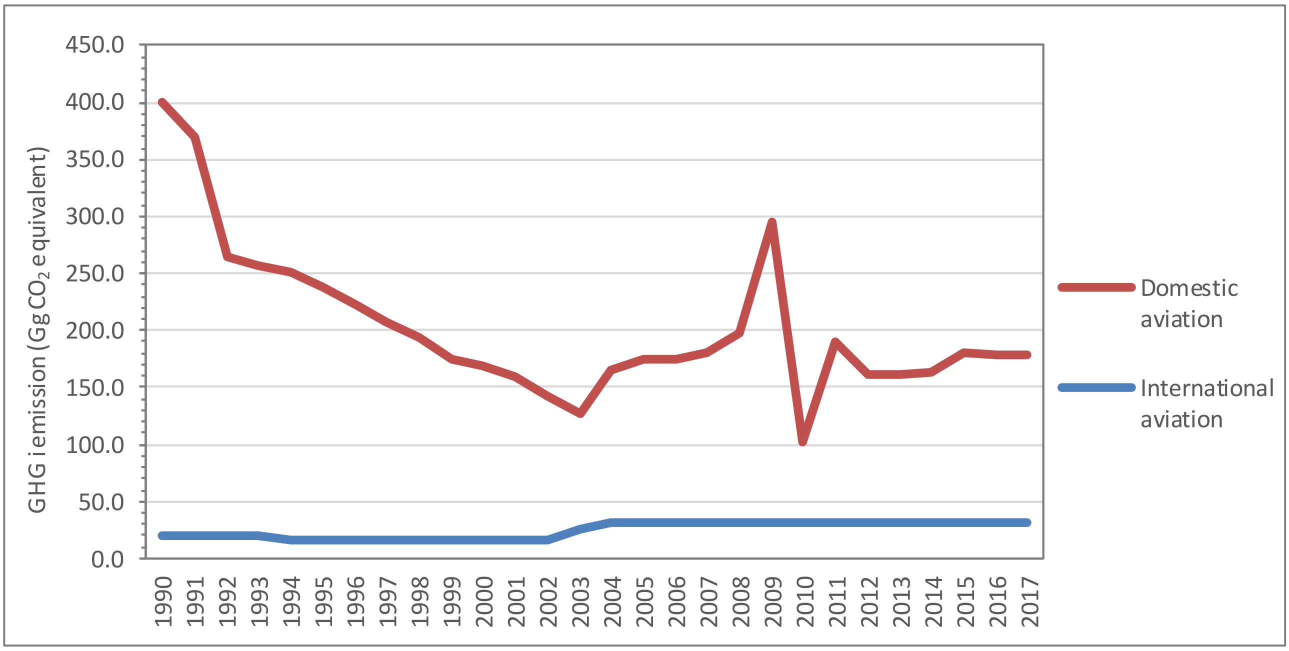


Figure 87 GHG Emissions from IPCC sub-category 1.A.3.a Domestic Aviation and International Aviation

Table 121 Emissions from IPCC sub-category 1.A.3.a.ii Domestic Aviation

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	400.80	397.30	0.06	3.45	NO
1991	368.99	365.77	0.05	3.17	NO
1992	264.02	261.71	0.04	2.27	NO
1993	257.66	255.41	0.04	2.21	NO
1994	251.30	249.10	0.04	2.16	NO
1995	238.57	236.49	0.03	2.05	NO
1996	222.67	220.72	0.03	1.91	NO
1997	206.76	204.95	0.03	1.78	NO
1998	194.04	192.34	0.03	1.67	NO
1999	174.95	173.42	0.03	1.50	NO
2000	168.59	167.12	0.02	1.45	NO
2001	159.05	157.66	0.02	1.37	NO
2002	143.14	141.89	0.02	1.23	NO
2003	127.24	126.13	0.02	1.09	NO
2004	165.41	163.96	0.02	1.42	NO
2005	174.95	173.42	0.03	1.50	NO
2006	174.95	173.42	0.03	1.50	NO
2007	181.31	179.73	0.03	1.56	NO
2008	197.22	195.50	0.03	1.70	NO
2009	295.83	293.24	0.04	2.54	NO

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
2010	101.79	100.90	0.01	0.87	NO
2011	190.86	189.19	0.03	1.64	NO
2012	162.23	160.81	0.02	1.39	NO
2013	162.23	160.81	0.02	1.39	NO
2014	163.82	162.39	0.02	1.41	NO
2015	179.72	178.15	0.03	1.54	NO
2016	179.41	177.84	0.03	1.54	NO
2017	179.41	177.84	0.03	1.54	NO
Trend					
1990 - 2017	*-55%*	*-55%*	*-55%*	*-55%*	-
2005 - 2017	*3%*	*3%*	*3%*	*3%*	-
2016 - 2017	*0%*	*0%*	*0%*	*0%*	-

3.2.7.1.2 Methodological issues

3.2.7.1.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[78] has been applied:

Equation 3.6.1: Aviation equation 1 (2006 IPCC GL, Vol. 2, Chap. 3)

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

Where:

Emissions $_{GHG,\ fuel}$ = emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$ = amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$ = default emission factor of a given GHG by type of fuel (kg gas/TJ)
For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG = CO_2, CH_4, N_2O

For estimating the air pollutants emissions (NO_x, CO, NMVOC, SO_2) the Tier 1 approach[79] of the Revised 1996 IPCC Guidelines has been applied:

Equation: Air pollutant emissions from stationary combustion

$$\boldsymbol{Emissions_{pollutant} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{pollutant,\,fuel}}$$

Where:

Emissions $_{pollutant}$ = emissions of a given pollutant by type of fuel (kg pollutant)
Fuel consumption $_{fuel}$ = amount of fuel combusted (TJ)
Emission factor $_{pollutant,\ fuel}$ = default emission factor of a given pollutant by type of fuel (g $_{pollutant}$/GJ).
Pollutant = NOx, CO, NMVOC, SO_2

[78] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 3: Mobil Combustion – 3.6.1.1 Methodological issues - Choice of method
[79] Source: Revised 1996 IPCC Guidelines, Reference Manual, Energy, Chap. 1.5.3.5 Aircraft.

3.2.7.1.2.2 Choice of activity data - International aviation

Liquid fuels: Kerosene-type Jet Fuel

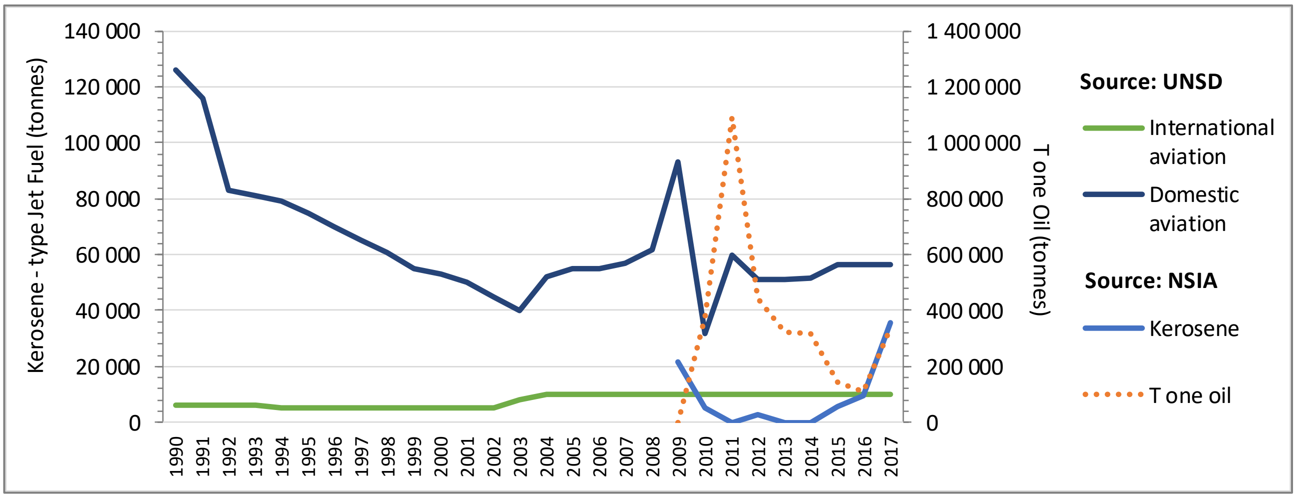


Figure 88 Activity data for IPCC sub-category 1.A.3.a Civil Aviation

The above figure presents the available national and international data of fuel consumption in IPCC sub-category 1.A.3.a Civil Aviation. The national and international data is not consistent. Afghanistan is importing Kerosene – type jet fuel and *T one oil*. According to national experts *T one oil* is used for aviation. However, the inconsistencies between the two data sets could not be solved, thus it was decided to use the data set from UN statistics.

The fuel consumption used for estimating the GHG and non-GHG emissions are taken for the years

- 1990 – 2016 from the UN Statistics Division (UNSD) - Energy Statistics Section.
- 2017 data of 2016 as this data was not available

The total fuel consumption increased by 67% in the period 1990 – 2017. From 2005 to 2017 the total fuel consumption was constant, even if annual fluctuations in fuel consumption could be observed. The decrease in fuel consumption and the annual fluctuations are due to decreased fuel consumption in this sector mainly due to the Afghan Civil War (1989–92, 1996–2001) and War in Afghanistan (2001–present).

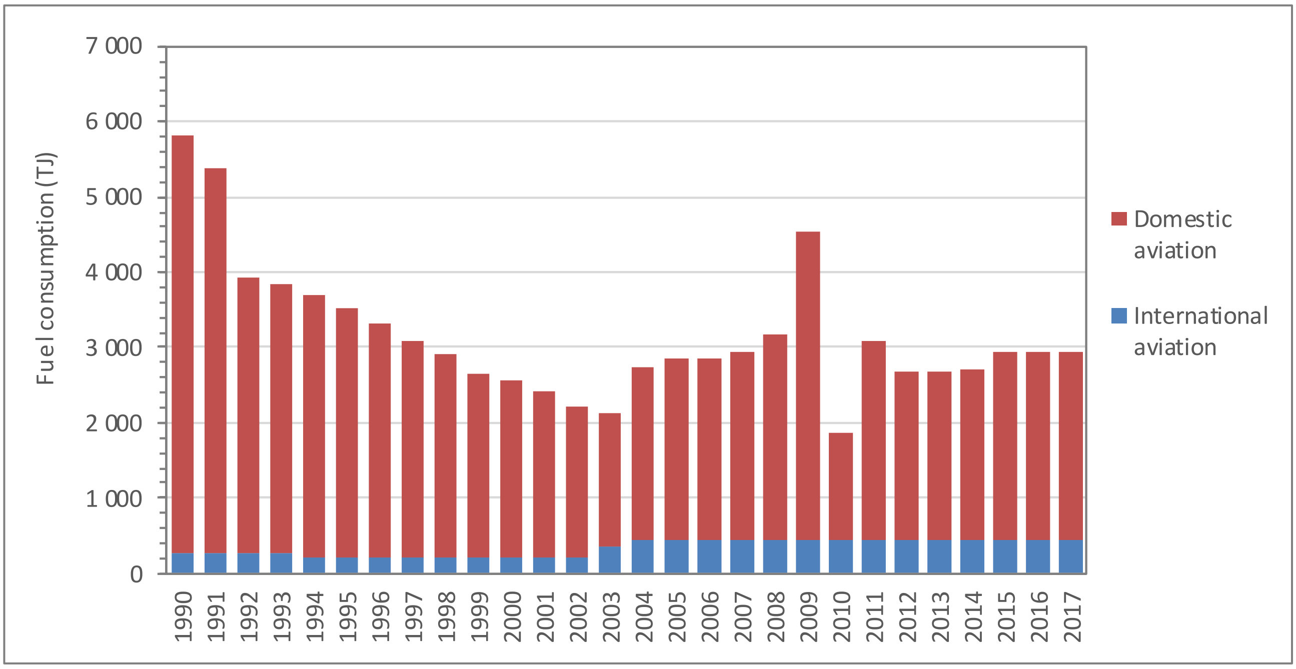


Figure 89 Activity data for IPCC sub-category 1.A.3 Domestic aviation and International Aviation

Table 122 Activity data for IPCC sub-category 1.A.3.a.ii Domestic Aviation

Activity data 1.A.3.a.ii	Total fuels (incl. biomass)	Liquid fuels			Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
			Kerosene-type Jet Fuel	Aviation gasoline					
	TJ								
1990	5,556.60	5,556.60	5,556.60	NO	NA	NA	NA	NA	NO
1991	5,115.60	5,115.60	5,115.60	NO	NA	NA	NA	NA	NO
1992	3,660.30	3,660.30	3,660.30	NO	NA	NA	NA	NA	NO
1993	3,572.10	3,572.10	3,572.10	NO	NA	NA	NA	NA	NO
1994	3,483.90	3,483.90	3,483.90	NO	NA	NA	NA	NA	NO
1995	3,307.50	3,307.50	3,307.50	NO	NA	NA	NA	NA	NO
1996	3,087.00	3,087.00	3,087.00	NO	NA	NA	NA	NA	NO
1997	2,866.50	2,866.50	2,866.50	NO	NA	NA	NA	NA	NO
1998	2,690.10	2,690.10	2,690.10	NO	NA	NA	NA	NA	NO
1999	2,425.50	2,425.50	2,425.50	NO	NA	NA	NA	NA	NO
2000	2,337.30	2,337.30	2,337.30	NO	NA	NA	NA	NA	NO
2001	2,205.00	2,205.00	2,205.00	NO	NA	NA	NA	NA	NO
2002	1,984.50	1,984.50	1,984.50	NO	NA	NA	NA	NA	NO
2003	1,764.00	1,764.00	1,764.00	NO	NA	NA	NA	NA	NO
2004	2,293.20	2,293.20	2,293.20	NO	NA	NA	NA	NA	NO
2005	2,425.50	2,425.50	2,425.50	NO	NA	NA	NA	NA	NO
2006	2,425.50	2,425.50	2,425.50	NO	NA	NA	NA	NA	NO
2007	2,513.70	2,513.70	2,513.70	NO	NA	NA	NA	NA	NO
2008	2,734.20	2,734.20	2,734.20	NO	NA	NA	NA	NA	NO
2009	4,101.30	4,101.30	4,101.30	NO	NA	NA	NA	NA	NO
2010	1,411.20	1,411.20	1,411.20	NO	NA	NA	NA	NA	NO

Activity data 1.A.3.a.ii	Total fuels (incl. biomass)	Liquid fuels			Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
			Kerosene-type Jet Fuel	Aviation gasoline					
	TJ								
2011	2,646.00	2,646.00	2,646.00	NO	NA	NA	NA	NA	NO
2012	2,249.10	2,249.10	2,249.10	NO	NA	NA	NA	NA	NO
2013	2,249.10	2,249.10	2,249.10	NO	NA	NA	NA	NA	NO
2014	2,271.15	2,271.15	2,271.15	NO	NA	NA	NA	NA	NO
2015	2,491.65	2,491.65	2,491.65	NO	NA	NA	NA	NA	NO
2016	2,487.24	2,487.24	2,487.24	NO	NA	NA	NA	NA	NO
2017	2,487.24	2,487.24	2,487.24	NO	NA	NA	NA	NA	NO
Trend									
1990 - 2017	*-55.2%*	*-55.2%*	*-55.2%*		-	-	-	-	-
2005 - 2017	*2.5%*	*2.5%*	*2.5%*		-	-	-	-	-
1990 - 2017	*0.0%*	*0.0%*	*0.0%*		-	-	-	-	-

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic metres. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.3.a. *Domestic aviation and International Aviation*.

Table 123 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.3.a. Domestic aviation and International Aviation

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Kerosene	liquid	44.10	D	**2006 IPCC Guidelines, Vol. 2, Chap. 1, Table 1.2** Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
Note:				
D Default	CS Country specific	PS Plant specific		

3.2.7.1.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 124 GHG Emission factor TIER 1 for IPCC sub-category 1.A.3.a. Civil Aviation

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	**2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)**
Kerosene (Jet fuel)	liquid	71 500	D					**TABLE 3.6.4** CO_2 emission factors (page 3.64)
				0.5	D	2	D	**TABLE 3.6.5** Non-CO_2 emission factors (page 3.64)
Note:								
D Default	CS Country specific	PS Plant specific	IEF Implied emission factor					

Default emission factors for air pollutant were taken from the EMEP/EEA air pollutant emission inventory Guidebook 2016 and are presented in the following table.

Table 125 Non-GHG Emission factor for IPCC sub-category 1.A.3.a.i International Aviation

Fuel	Fuel type	NOx (g/GJ)		CO (g/GJ)		NMVOC (g/GJ)		SO_2 (g/GJ)		Source
		EF	type	EF	type	EF	type	EF	type	**EMEP/EEA Guidebook 2016, Part B, Vol 1 - 1A, chap. 1.A.3.a, 1.A.5.b Aviation**
Kerosene	liquid	4	D	1200	D	19	D	1	D	**Table 3-3** Tier 1 emission factors for NFR 1.A.3.a.ii.(i): Civil aviation (domestic, LTO) (page. 16)
Note:										
D Default		CS Country specific			PS Plant specific			IEF Implied emission factor		

3.2.7.1.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.3.a.i *International Aviation* are presented in the following table.

Table 126 Uncertainty for IPCC sub-category 1.A.3.a.i International Aviation.

Uncertainty	Liquid fuels			Reference
	CO_2	CH_4	N_2O	
Activity data (AD)	10%	10%	10%	2006 IPCC GL, Vol. 2, Chap. 3 (3.6.1.7)
Emission factor (EF)	5%	22%	40%	
Combined Uncertainty (U)	12%	100%	22%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.2.7.1.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data,
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.7.1.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category 1.A.2.m *Other*.

Table 127 Recalculations done since SNC in IPCC sub-category 1.A.3.a.i International Aviation

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.3.a	Fuel consumption data (activity data) was revised due to • revised activity data • consideration of imported fuels (reported by importers)(UNSD)	AD	Accuracy
1.A.3.a	use of default NCV of 2006 IPCC Guidelines	AD	Comparability
1.A.3.a	use of default EF of 2006 IPCC Guidelines	EF	Comparability
1.A.3.a	application of 2006 IPCC Guidelines	method	Comparability

3.2.7.1.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 128 Planned improvements for IPCC sub-category 1.A.3.a.i International Aviation

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.3.a	Survey on domestic and international fuel consumption totals (Aviation gasoline consumption, Jet Fuel consumption, *T one oil* etc.): • annual amount of fuel consumption by fuel type for • country specific Net Caloric Value (NCV) for imported fuels ⇒ conversion from mass unit to energy unit (unit EF is kg /TJ) • Carbon content (%) of gas/diesel oil, residual fuel oil, natural gas etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	AD	Completeness Accuracy Transparency	high
1.A.3.a	Cross-check of national and international data sources and feedback to UNSD	AD	Completeness Consistency Transparency	medium
1.A.3.a	Time-series of fuel consumption ⇒ completing time series and gap filling for some years	AD	Consistency Completeness	high
1.A.3.a	• LTO by aircraft type • Origin and Destination (OD) by aircraft type	AD	Accuracy Consistency	high
1.A.3.a	Full flight movements with aircraft and engine data		Accuracy Consistency	medium

3.2.7.2 Road Transportation (IPCC category 1.A.3.b)

3.2.7.2.1 Source category description

This section describes GHG emissions resulting from fuel combustion in Road Transport (IPCC category 1.A.3.b). The mobile source category *Road Transportation* includes all types of light-duty vehicles such as automobiles and light trucks, and heavy-duty vehicles such as tractor trailers and buses, and on-road motorcycles (including mopeds, scooters, and three-wheelers).

IPCC code	Description	Key categories		
		CO_2	CH_4	N_2O
1.A.3.b	Road Transportation			
1.A.3.b.i	Cars	LA 1990, 20177, TA	-	-
1.A.3.b.i.1	Passenger cars with 3-way catalysts	-	-	-
1.A.3.b.i.2	Passenger cars without 3-way catalysts	-	-	-
1.A.3.b.ii	Light-duty trucks	LA 20177, TA	-	-
1.A.3.b.ii.1	Light-duty trucks with 3-way catalysts	-	-	-
1.A.3.b.ii.2	Light-duty trucks without 3-way catalysts	-	-	-
1.A.3.b.iii	Heavy-duty trucks and buses	LA 1990, 2017, TA	-	LA 2017
1.A.3.b.iv	Motorcycles	LA 1990, 20177, TA	-	-
1.A.3.b.v	Evaporative emissions from vehicles	-	-	-
1.A.3.b.vi	Urea-based catalysts	-	-	-
Key Category: LA – Level Assessment (in year); TA – Trend Assessment				

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.3.b																		
1.A.3.b.i	✓	NA	NO	NA	NA	NO	✓	NA	NO	NA	NA	NO	✓	NA	NO	NA	NA	NO
1.A.3.b.i.1	IE	NA	NO	NA	NA	NO	IE	NA	NO	NA	NA	NO	IE	NA	NO	NA	NA	NO
1.A.3.b.i.2	IE	NA	NO	NA	NA	NO	IE	NA	NO	NA	NA	NO	IE	NA	NO	NA	NA	NO
1.A.3.b.ii	✓	NA	NO	NA	NA	NO	✓	NA	NO	NA	NA	NO	✓	NA	NO	NA	NA	NO
1.A.3.b.ii.1	IE	NA	NO	NA	NA	NO	IE	NA	NO	NA	NA	NO	IE	NA	NO	NA	NA	NO
1.A.3.b.ii.2	IE	NA	NO	NA	NA	NO	IE	NA	NO	NA	NA	NO	IE	NA	NO	NA	NA	NO
1.A.3.b.iii	✓	NA	NO	NA	NA	NO	✓	NA	NO	NA	NA	NO	✓	NA	NO	NA	NA	NO
1.A.3.b.iv	✓	NA	NO	NA	NA	NO	✓	NA	NO	NA	NA	NO	✓	NA	NO	NA	NA	NO
1.A.3.b.v	NA	NA	NA	NA	NA	NO	NA	NA	NO	NA	NA	NO	NA	NA	NO	NA	NA	NO
1.A.3.b.vi	NE	NA	NO	NA	NA	NO	NE	NA	NO	NA	NA	NO	NE	NA	NO	NA	NA	NO

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

Emissions from the IPCC sub-category 1.A.3.b Road transport are an important source of GHGs in Afghanistan:

- in 1990 about 21.0% of the total national GHG emissions and 71.6% of total CO_2 emissions arose from the *Road transport*, whereas CH_4 and N_2O emissions only make up about 0.2% and 1.7%, respectively.
- in 2005 about 17.2% of the total national GHG emissions and 79.1% of total CO_2 emissions arose from the *Road transport*, whereas CH_4 and N_2O emissions only make up less than 0.1% and 1.1%, respectively.
- in 2017 about 29.8% of the total national GHG emissions and 60.7% of total CO_2 emissions arose from the *Road transport*, whereas CH_4 and N_2O emissions only make up about 0.4% and 3.0%, respectively.

In the period 1990 to 2017 GHG emissions from the IPCC category 1.A.3.b Road transport increased by 241.9% from 3,789.43 Gg CO_2 eq in 1990 to 12,957.26 Gg CO_2 eq in 2017.

In the period 2005 to 2017 GHG emissions from the IPCC category 1.A.3.b Road transport increased by 236.3% from 3,852.48 Gg CO_2 eq in 2005 to 12,957.26 Gg CO_2 eq in 2017.

In the period 2016 to 2017 GHG emissions from the IPCC category 1.A.3.b Road transport remain stable.

The decrease in GHG emissions and the annual fluctuations of the emissions are due to decreased fuel consumption in this sector mainly due to the Afghan Civil War (1989–92, 1996–2001) and War in Afghanistan (2001–present). After 2002 the GHG emissions increased significantly to increased number of private vehicles, transport of goods, and increasing traveling within the country with both, private vehicles and public buses.

An overview of the GHG emissions from IPCC sub-category 1.A.3.b Road transport are provided in the following figure and tables.

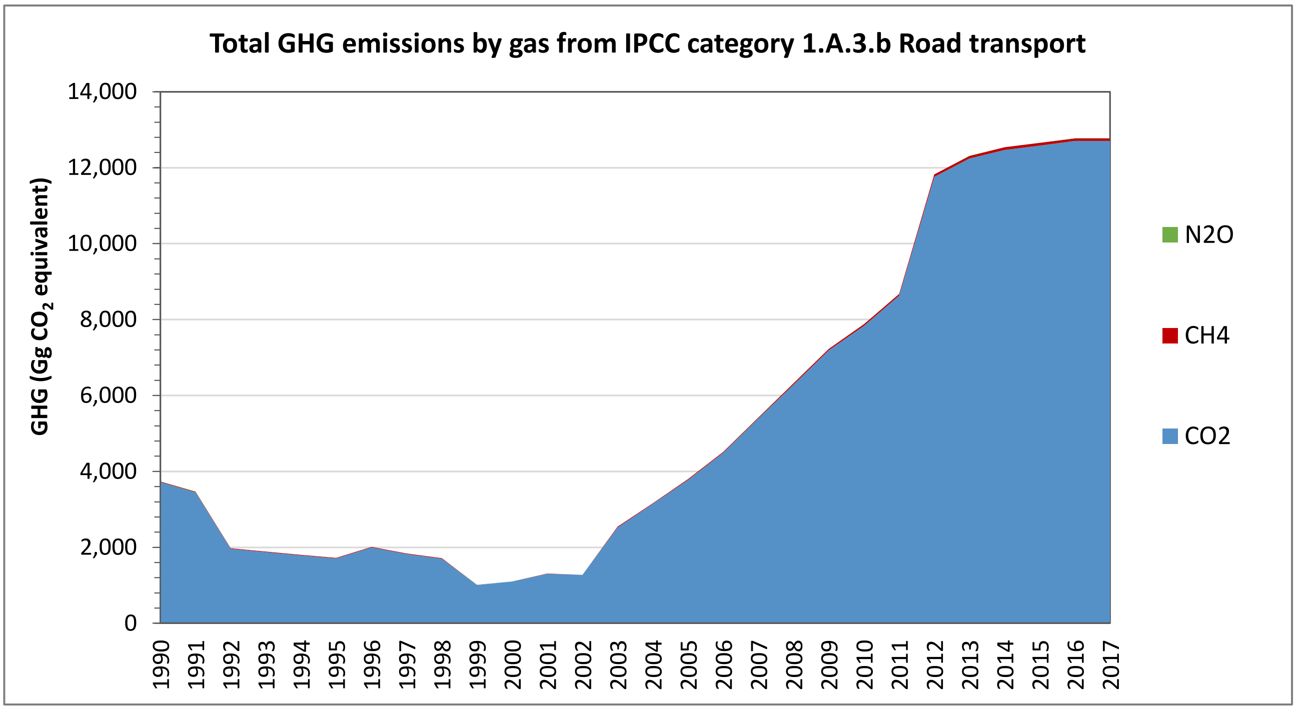


Figure 90 GHG Emissions by gas from IPCC sub-category 1.A.3.b Road transport

Table 129 Emissions from IPCC sub-category 1.A.3.b Road transport

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	3,789.43	3,717.22	15.91	56.30	NO
1991	3,519.43	3,452.36	14.78	52.29	NO
1992	2,004.94	1,962.85	13.25	28.85	NO
1993	1,914.94	1,874.56	12.87	27.51	NO
1994	1,825.31	1,786.74	12.36	26.20	NO
1995	1,748.27	1,711.20	12.00	25.07	NO
1996	2,041.81	1,998.52	14.01	29.28	NO
1997	1,865.88	1,826.18	12.97	26.72	NO
1998	1,738.09	1,701.06	12.15	24.88	NO
1999	1,026.07	1,007.66	2.89	15.52	NO
2000	1,120.53	1,099.76	3.98	16.79	NO
2001	1,331.10	1,305.87	5.42	19.81	NO
2002	1,296.07	1,272.52	4.01	19.53	NO
2003	2,583.52	2,528.56	17.96	37.00	NO
2004	3,205.56	3,144.21	13.80	47.56	NO
2005	3,852.48	3,778.31	17.12	57.05	NO
2006	4,580.18	4,491.50	20.96	67.71	NO
2007	5,498.70	5,391.49	26.63	80.59	NO
2008	6,417.23	6,291.48	32.29	93.46	NO
2009	7,335.76	7,191.47	37.95	106.34	NO
2010	7,992.42	7,834.97	41.69	115.76	NO
2011	8,800.94	8,628.02	45.31	127.62	NO
2012	11,994.38	11,758.67	66.33	169.38	NO
2013	12,487.34	12,242.16	68.69	176.49	NO
2014	12,717.15	12,467.64	69.67	179.85	NO
2015	12,835.63	12,583.81	70.26	181.56	NO
2016	12,957.26	12,703.16	70.73	183.38	NO
2017	12,957.26	12,703.16	70.73	183.38	NO
Trend					
1990 - 2017	*241.9%*	*241.7%*	*344.5%*	*225.7%*	-
2005 - 2017	*236.3%*	*236.2%*	*313.2%*	*221.4%*	-
2012 - 2017	*8.0%*	*8.0%*	*6.6%*	*8.3%*	-
2016 - 2017	*0.0%*	*0.0%*	*0.0%*	*0.0%*	-

An overview of the GHG emissions from IPCC sub-category 1.A.3.b Road transport are provided in the following figure and tables.

In 2017 the most important sources of GHGs in the sub-category *Road transport* are

- *Heavy-duty trucks and buses* with 53.1%,
- *Passenger Cars* with 39.3%,
- Motorcycles with 4.1%, and
- Light-duty trucks with 2.1%.

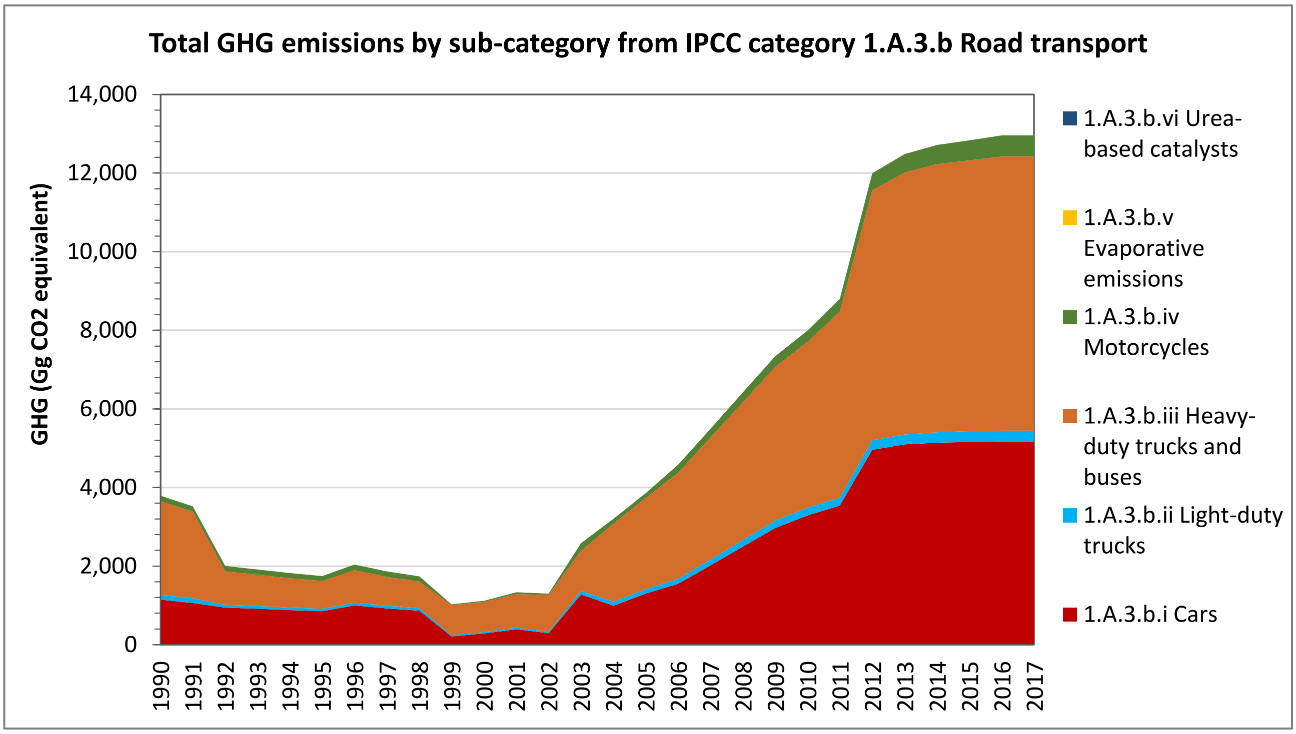


Figure 91 GHG Emissions by gas from IPCC sub-category 1.A.3.b Road transport

Table 130 GHG Emissions by sub-category from IPCC sub-category 1.A.3.b Road transport

GHG emissions	1.A.3.b	1.A.3.b.i	1.A.3.b.i.1	1.A.3.b.i.2	1.A.3.b.ii	1.A.3.b.ii.1	1.A.3.b.ii.2	1.A.3.b.iii	1.A.3.b.iv	1.A.3.b.v	1.A.3.b.vi
	Road Transportation	Cars	Passenger cars with 3-way catalysts	Passenger cars without 3-way catalysts	Light-duty trucks	Light-duty trucks with 3-way catalysts	Light-duty trucks without 3-way catalysts	Heavy-duty trucks and buses	Motorcycles	Evaporative emissions	Urea-based catalysts
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	3,789.43	1,143.61	IE	IE	124.11	IE	IE	2,376.21	145.50	NA	NE
1991	3,519.43	1,062.47	IE	IE	115.27	IE	IE	2,206.48	135.20	NA	NE
1992	2,004.94	943.51	IE	IE	72.01	IE	IE	848.65	140.78	NA	NE
1993	1,914.94	916.47	IE	IE	69.06	IE	IE	792.07	137.34	NA	NE
1994	1,825.31	880.35	IE	IE	65.96	IE	IE	746.81	132.19	NA	NE
1995	1,748.27	854.58	IE	IE	63.38	IE	IE	701.55	128.76	NA	NE
1996	2,041.81	997.22	IE	IE	74.01	IE	IE	820.36	150.22	NA	NE
1997	1,865.88	923.04	IE	IE	67.85	IE	IE	735.49	139.49	NA	NE
1998	1,738.09	864.96	IE	IE	63.30	IE	IE	678.92	130.91	NA	NE
1999	1,026.07	209.95	IE	IE	31.74	IE	IE	763.78	20.60	NA	NE
2000	1,120.53	287.52	IE	IE	35.75	IE	IE	763.78	33.48	NA	NE
2001	1,331.10	390.15	IE	IE	43.38	IE	IE	848.65	48.93	NA	NE
2002	1,296.07	291.08	IE	IE	40.57	IE	IE	933.51	30.90	NA	NE
2003	2,583.52	1,278.05	IE	IE	93.95	IE	IE	1,018.38	193.14	NA	NE
2004	3,205.56	991.06	IE	IE	105.43	IE	IE	1,981.53	127.54	NA	NE
2005	3,852.48	1,301.50	IE	IE	108.40	IE	IE	2,316.18	126.40	NA	NE
2006	4,580.18	1,547.71	IE	IE	126.01	IE	IE	2,695.94	210.51	NA	NE
2007	5,498.70	2,021.45	IE	IE	145.98	IE	IE	3,101.33	229.94	NA	NE
2008	6,417.23	2,495.18	IE	IE	165.96	IE	IE	3,506.72	249.38	NA	NE
2009	7,335.76	2,968.92	IE	IE	185.93	IE	IE	3,912.10	268.81	NA	NE

GHG emissions	1.A.3.b	1.A.3.b.i	1.A.3.b.i.1	1.A.3.b.i.2	1.A.3.b.ii	1.A.3.b.ii.1	1.A.3.b.ii.2	1.A.3.b.iii	1.A.3.b.iv	1.A.3.b.v	1.A.3.b.vi
	Road Transportation	Cars	Passenger cars with 3-way catalysts	Passenger cars without 3-way catalysts	Light-duty trucks	Light-duty trucks with 3-way catalysts	Light-duty trucks without 3-way catalysts	Heavy-duty trucks and buses	Motorcycles	Evaporative emissions	Urea-based catalysts
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
2010	7,992.42	3,290.21	IE	IE	194.38	IE	IE	4,225.05	282.78	NA	NE
2011	8,800.94	3,540.34	IE	IE	202.46	IE	IE	4,733.99	324.15	NA	NE
2012	11,994.38	4,955.11	IE	IE	246.83	IE	IE	6,363.39	429.05	NA	NE
2013	12,487.34	5,094.27	IE	IE	254.74	IE	IE	6,668.68	469.65	NA	NE
2014	12,717.15	5,140.42	IE	IE	265.27	IE	IE	6,820.70	490.77	NA	NE
2015	12,835.63	5,161.39	IE	IE	271.55	IE	IE	6,890.90	511.80	NA	NE
2016	12,957.26	5,165.58	IE	IE	277.79	IE	IE	6,977.92	535.97	NA	NE
2017	12,957.26	5,165.58	IE	IE	277.79	IE	IE	6,977.92	535.97	NA	NE
Trend											
1990 - 2017	*241.9%*	*351.7%*	*NA*	*NA*	*123.8%*	*NA*	*NA*	*193.7%*	*268.4%*	*NA*	*NA*
2005 - 2017	*236.3%*	*296.9%*	*NA*	*NA*	*156.3%*	*NA*	*NA*	*201.3%*	*324.0%*	*NA*	*NA*
2012 - 2017	*8.0%*	*4.2%*	*NA*	*NA*	*12.5%*	*NA*	*NA*	*9.7%*	*24.9%*	*NA*	*NA*
2016 - 2017	*0.0%*	*0.0%*	*NA*	*NA*	*0.0%*	*NA*	*NA*	*0.0%*	*0.0%*	*NA*	*NA*

Table 131 CO_2 Emissions by sub-category from IPCC sub-category 1.A.3.b Road transport

CO_2 emissions	1.A.3.b	1.A.3.b.i	1.A.3.b.i.1	1.A.3.b.i.2	1.A.3.b.ii	1.A.3.b.ii.1	1.A.3.b.ii.2	1.A.3.b.iii	1.A.3.b.iv	1.A.3.b.v	1.A.3.b.vi
	Road Transportation	Cars	Passenger cars with 3-way catalysts	Passenger cars without 3-way catalysts	Light-duty trucks	Light-duty trucks with 3-way catalysts	Light-duty trucks without 3-way catalysts	Heavy-duty trucks and buses	Motorcycles	Evaporative emissions	Urea-based catalysts
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	3,717.22	1,117.21	IE	IE	121.66	IE	IE	2,336.49	141.86	NA	NE
1991	3,452.36	1,037.95	IE	IE	113.00	IE	IE	2,169.60	131.81	NA	NE
1992	1,962.85	920.69	IE	IE	70.44	IE	IE	834.46	137.25	NA	NE
1993	1,874.56	894.27	IE	IE	67.55	IE	IE	778.83	133.91	NA	NE
1994	1,786.74	859.02	IE	IE	64.51	IE	IE	734.33	128.88	NA	NE
1995	1,711.20	833.85	IE	IE	61.99	IE	IE	689.82	125.54	NA	NE
1996	1,998.52	973.03	IE	IE	72.39	IE	IE	806.65	146.46	NA	NE
1997	1,826.18	900.63	IE	IE	66.36	IE	IE	723.20	136.00	NA	NE
1998	1,701.06	843.95	IE	IE	61.91	IE	IE	667.57	127.63	NA	NE
1999	1,007.66	205.40	IE	IE	31.15	IE	IE	751.02	20.09	NA	NE
2000	1,099.76	281.04	IE	IE	35.07	IE	IE	751.02	32.64	NA	NE
2001	1,305.87	381.17	IE	IE	42.53	IE	IE	834.46	47.70	NA	NE
2002	1,272.52	284.66	IE	IE	39.82	IE	IE	917.91	30.13	NA	NE
2003	2,528.56	1,247.02	IE	IE	91.88	IE	IE	1,001.35	188.31	NA	NE
2004	3,144.21	968.11	IE	IE	103.34	IE	IE	1,948.41	124.35	NA	NE
2005	3,778.31	1,271.36	IE	IE	106.24	IE	IE	2,277.46	123.24	NA	NE
2006	4,491.50	1,511.87	IE	IE	123.51	IE	IE	2,650.88	205.24	NA	NE
2007	5,391.49	1,974.73	IE	IE	143.09	IE	IE	3,049.49	224.19	NA	NE
2008	6,291.48	2,437.58	IE	IE	162.66	IE	IE	3,448.10	243.13	NA	NE
2009	7,191.47	2,900.44	IE	IE	182.24	IE	IE	3,846.71	262.08	NA	NE

CO_2 emissions	1.A.3.b	1.A.3.b.i	1.A.3.b.i.1	1.A.3.b.i.2	1.A.3.b.ii	1.A.3.b.ii.1	1.A.3.b.ii.2	1.A.3.b.iii	1.A.3.b.iv	1.A.3.b.v	1.A.3.b.vi
	Road Transportation	Cars	Passenger cars with 3-way catalysts	Passenger cars without 3-way catalysts	Light-duty trucks	Light-duty trucks with 3-way catalysts	Light-duty trucks without 3-way catalysts	Heavy-duty trucks and buses	Motorcycles	Evaporative emissions	Urea-based catalysts
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
2010	7,834.97	3,214.31	IE	IE	190.52	IE	IE	4,154.43	275.70	NA	NE
2011	8,628.02	3,458.67	IE	IE	198.45	IE	IE	4,654.86	316.04	NA	NE
2012	11,758.67	4,841.41	IE	IE	241.93	IE	IE	6,257.02	418.32	NA	NE
2013	12,242.16	4,977.37	IE	IE	249.68	IE	IE	6,557.21	457.90	NA	NE
2014	12,467.64	5,022.46	IE	IE	260.00	IE	IE	6,706.68	478.49	NA	NE
2015	12,583.81	5,042.94	IE	IE	266.16	IE	IE	6,775.71	499.00	NA	NE
2016	12,703.16	5,047.04	IE	IE	272.28	IE	IE	6,861.28	522.56	NA	NE
2017	12,703.16	5,047.04	IE	IE	272.28	IE	IE	6,861.28	522.56	NA	NE
Trend											
1990 - 2017	*241.7%*	*351.8%*	*NA*	*NA*	*123.8%*	*NA*	*NA*	*193.7%*	*268.4%*	*NA*	*NA*
2005 - 2017	*236.2%*	*297.0%*	*NA*	*NA*	*156.3%*	*NA*	*NA*	*201.3%*	*324.0%*	*NA*	*NA*
2012 - 2017	*8.0%*	*4.2%*	*NA*	*NA*	*12.5%*	*NA*	*NA*	*9.7%*	*24.9%*	*NA*	*NA*
2016 - 2017	*0.0%*	*0.0%*	*NA*	*NA*	*0.0%*	*NA*	*NA*	*0.0%*	*0.0%*	*NA*	*NA*

Table 132 CH_4 Emissions by sub-category from IPCC sub-category 1.A.3.b Road transport

CH_4 emissions	1.A.3.b	1.A.3.b.i	1.A.3.b.i.1	1.A.3.b.i.2	1.A.3.b.ii	1.A.3.b.ii.1	1.A.3.b.ii.2	1.A.3.b.iii	1.A.3.b.iv	1.A.3.b.v	1.A.3.b.vi
	Road Transportation	Cars	Passenger cars with 3-way catalysts	Passenger cars without 3-way catalysts	Light-duty trucks	Light-duty trucks with 3-way catalysts	Light-duty trucks without 3-way catalysts	Heavy-duty trucks and buses	Motorcycles	Evaporative emissions	Urea-based catalysts
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	0.64	0.42	IE	IE	0.03	IE	IE	0.12	0.07	NA	NA
1991	0.59	0.39	IE	IE	0.02	IE	IE	0.11	0.06	NA	NA
1992	0.53	0.40	IE	IE	0.02	IE	IE	0.04	0.07	NA	NA
1993	0.51	0.39	IE	IE	0.02	IE	IE	0.04	0.06	NA	NA
1994	0.49	0.37	IE	IE	0.02	IE	IE	0.04	0.06	NA	NA
1995	0.48	0.36	IE	IE	0.02	IE	IE	0.04	0.06	NA	NA
1996	0.56	0.42	IE	IE	0.02	IE	IE	0.04	0.07	NA	NA
1997	0.52	0.39	IE	IE	0.02	IE	IE	0.04	0.06	NA	NA
1998	0.49	0.37	IE	IE	0.02	IE	IE	0.04	0.06	NA	NA
1999	0.12	0.06	IE	IE	0.00	IE	IE	0.04	0.01	NA	NA
2000	0.16	0.10	IE	IE	0.01	IE	IE	0.04	0.02	NA	NA
2001	0.22	0.14	IE	IE	0.01	IE	IE	0.04	0.02	NA	NA
2002	0.16	0.09	IE	IE	0.01	IE	IE	0.05	0.01	NA	NA
2003	0.72	0.55	IE	IE	0.03	IE	IE	0.05	0.09	NA	NA
2004	0.55	0.37	IE	IE	0.02	IE	IE	0.10	0.06	NA	NA
2005	0.68	0.48	IE	IE	0.02	IE	IE	0.12	0.06	NA	NA
2006	0.84	0.58	IE	IE	0.03	IE	IE	0.14	0.10	NA	NA
2007	1.07	0.77	IE	IE	0.03	IE	IE	0.16	0.11	NA	NA
2008	1.29	0.96	IE	IE	0.03	IE	IE	0.18	0.12	NA	NA
2009	1.52	1.15	IE	IE	0.04	IE	IE	0.20	0.12	NA	NA

CH_4 emissions	1.A.3.b	1.A.3.b.i	1.A.3.b.i.1	1.A.3.b.i.2	1.A.3.b.ii	1.A.3.b.ii.1	1.A.3.b.ii.2	1.A.3.b.iii	1.A.3.b.iv	1.A.3.b.v	1.A.3.b.vi
	Road Transportation	Cars	Passenger cars with 3-way catalysts	Passenger cars without 3-way catalysts	Light-duty trucks	Light-duty trucks with 3-way catalysts	Light-duty trucks without 3-way catalysts	Heavy-duty trucks and buses	Motorcycles	Evaporative emissions	Urea-based catalysts
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
2010	1.67	1.28	IE	IE	0.04	IE	IE	0.22	0.13	NA	NA
2011	1.81	1.37	IE	IE	0.04	IE	IE	0.24	0.15	NA	NA
2012	2.65	2.07	IE	IE	0.05	IE	IE	0.33	0.20	NA	NA
2013	2.75	2.13	IE	IE	0.05	IE	IE	0.35	0.22	NA	NA
2014	2.79	2.15	IE	IE	0.05	IE	IE	0.35	0.23	NA	NA
2015	2.81	2.16	IE	IE	0.06	IE	IE	0.36	0.24	NA	NA
2016	2.83	2.16	IE	IE	0.06	IE	IE	0.36	0.25	NA	NA
2017	2.83	2.16	IE	IE	0.06	IE	IE	0.36	0.25	NA	NA
Trend											
1990 - 2017	*344.5%*	*413.7%*	*NA*	*NA*	*129.1%*	*NA*	*NA*	*193.7%*	*268.4%*	*NA*	*NA*
2005 - 2017	*313.2%*	*346.9%*	*NA*	*NA*	*156.3%*	*NA*	*NA*	*201.3%*	*324.0%*	*NA*	*NA*
2012 - 2017	*6.6%*	*4.3%*	*NA*	*NA*	*12.5%*	*NA*	*NA*	*9.7%*	*24.9%*	*NA*	*NA*
2016 - 2017	*0.0%*	*0.0%*	*NA*	*NA*	*0.0%*	*NA*	*NA*	*0.0%*	*0.0%*	*NA*	*NA*

Table 133 N2 Emissions by sub-category from IPCC sub-category 1.A.3.b Road transport

N_2O emissions	1.A.3.b	1.A.3.b.i	1.A.3.b.i.1	1.A.3.b.i.2	1.A.3.b.ii	1.A.3.b.ii.1	1.A.3.b.ii.2	1.A.3.b.iii	1.A.3.b.iv	1.A.3.b.v	1.A.3.b.vi
	Road Transportation	Cars	Passenger cars with 3-way catalysts	Passenger cars without 3-way catalysts	Light-duty trucks	Light-duty trucks with 3-way catalysts	Light-duty trucks without 3-way catalysts	Heavy-duty trucks and buses	Motorcycles	Evaporative emissions	Urea-based catalysts
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	0.19	0.05	IE	IE	0.01	IE	IE	0.12	0.01	NA	NE
1991	0.18	0.05	IE	IE	0.01	IE	IE	0.11	0.01	NA	NE
1992	0.10	0.04	IE	IE	0.00	IE	IE	0.04	0.01	NA	NE
1993	0.09	0.04	IE	IE	0.00	IE	IE	0.04	0.01	NA	NE
1994	0.09	0.04	IE	IE	0.00	IE	IE	0.04	0.01	NA	NE
1995	0.08	0.04	IE	IE	0.00	IE	IE	0.04	0.01	NA	NE
1996	0.10	0.05	IE	IE	0.00	IE	IE	0.04	0.01	NA	NE
1997	0.09	0.04	IE	IE	0.00	IE	IE	0.04	0.01	NA	NE
1998	0.08	0.04	IE	IE	0.00	IE	IE	0.04	0.01	NA	NE
1999	0.05	0.01	IE	IE	0.00	IE	IE	0.04	0.00	NA	NE
2000	0.06	0.01	IE	IE	0.00	IE	IE	0.04	0.00	NA	NE
2001	0.07	0.02	IE	IE	0.00	IE	IE	0.04	0.00	NA	NE
2002	0.07	0.01	IE	IE	0.00	IE	IE	0.05	0.00	NA	NE
2003	0.12	0.06	IE	IE	0.00	IE	IE	0.05	0.01	NA	NE
2004	0.16	0.05	IE	IE	0.01	IE	IE	0.10	0.01	NA	NE
2005	0.19	0.06	IE	IE	0.01	IE	IE	0.12	0.01	NA	NE
2006	0.23	0.07	IE	IE	0.01	IE	IE	0.14	0.01	NA	NE
2007	0.27	0.09	IE	IE	0.01	IE	IE	0.16	0.01	NA	NE
2008	0.31	0.11	IE	IE	0.01	IE	IE	0.18	0.01	NA	NE
2009	0.36	0.13	IE	IE	0.01	IE	IE	0.20	0.01	NA	NE

N_2O emissions	1.A.3.b	1.A.3.b.i	1.A.3.b.i.1	1.A.3.b.i.2	1.A.3.b.ii	1.A.3.b.ii.1	1.A.3.b.ii.2	1.A.3.b.iii	1.A.3.b.iv	1.A.3.b.v	1.A.3.b.vi
	Road Transportation	Cars	Passenger cars with 3-way catalysts	Passenger cars without 3-way catalysts	Light-duty trucks	Light-duty trucks with 3-way catalysts	Light-duty trucks without 3-way catalysts	Heavy-duty trucks and buses	Motorcycles	Evaporative emissions	Urea-based catalysts
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
2010	0.39	0.15	IE	IE	0.01	IE	IE	0.22	0.01	NA	NE
2011	0.43	0.16	IE	IE	0.01	IE	IE	0.24	0.01	NA	NE
2012	0.57	0.21	IE	IE	0.01	IE	IE	0.33	0.02	NA	NE
2013	0.59	0.21	IE	IE	0.01	IE	IE	0.35	0.02	NA	NE
2014	0.60	0.22	IE	IE	0.01	IE	IE	0.35	0.02	NA	NE
2015	0.61	0.22	IE	IE	0.01	IE	IE	0.36	0.02	NA	NE
2016	0.62	0.22	IE	IE	0.01	IE	IE	0.36	0.02	NA	NE
2017	0.62	0.22	IE	IE	0.01	IE	IE	0.36	0.02	NA	NE
Trend											
1990 - 2017	*225.7%*	*306.2%*	*NA*	*NA*	*123.5%*	*NA*	*NA*	*193.7%*	*268.4%*	*NA*	*NA*
2005 - 2017	*221.4%*	*257.4%*	*NA*	*NA*	*156.3%*	*NA*	*NA*	*201.3%*	*324.0%*	*NA*	*NA*
2012 - 2017	*8.3%*	*4.2%*	*NA*	*NA*	*12.5%*	*NA*	*NA*	*9.7%*	*24.9%*	*NA*	*NA*
2016 - 2017	*0.0%*	*0.0%*	*NA*	*NA*	*0.0%*	*NA*	*NA*	*0.0%*	*0.0%*	*NA*	*NA*

3.2.7.2.2 Methodological issues

3.2.7.2.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[80] has been applied:

Equation 3.2.1: CO_2 from road transport (2006 IPCC GL, Vol. 2, Chap. 3)

$$\boldsymbol{CO_2 emission = \sum_a [Fuel_a \times EF_a]}$$

Where:

Emissions $_{CO2}$	= emissions of CO_2 (kg)
Fuel	= amount of fuel combusted (TJ)
Emission factor $_{CO2, fuel}$	= default CO_2 emission factor by fuel type (kg gas/TJ) Default EF CO_2 includes the carbon oxidation factor, assumed to be 1, and multiplied by 44/12.
a	= fuel type: e.g. Gas/ Diesel Oil, Motor Gasoline, Liquefied Petroleum Gases (LPG)

Equation 3.2.3: CH_4 and N_2O from road transport (2006 IPCC GL, Vol. 2, Chap. 3)

$$\boldsymbol{Emission = \sum_a [Fuel_a \times EF_a]}$$

Where:

Emissions $_{GHG}$	= emissions of CH_4 or N_2O (kg)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG, fuel}$	= default CH_4 or N_2O emission factor (kg gas/TJ)
a	= fuel type: e.g. Gas/ Diesel Oil, Motor Gasoline, Liquefied Petroleum Gases (LPG)

For estimating the air pollutants emissions (NO_x, CO, NMVOC, SO_2) the Tier 1 approach[81] of the EMEP/EEA air pollutant emission inventory guidebook 2016 has been applied:

Equation: Air pollutant emissions from stationary combustion

$$\boldsymbol{Emissions_{pollutant} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{pollutant,\ fuel}}$$

Where:

Emissions $_{pollutant}$	= emissions of a given pollutant by type of fuel (kg pollutant)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{pollutant, fuel}$	= default emission factor of a given pollutant by type of fuel (g $_{pollutant}$/GJ).
Pollutant	= NOx, CO, NMVOC, SO_2

[80] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 3: Mobil Combustion – 3.2.1.1 Methodological issues - Choice of method, page 3.12.
[81] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, 1.A.3.b.i-iv Road transport 201, sub-chapter 3.2.1 Tier 1 default approach.

3.2.7.2.2.2 Choice of activity data

Liquid fuels: Gas oil / Diesel oil

Liquid fuels: Gasoline

Liquid fuels: LPG

The fuel consumption used for estimating the GHG and non-GHG emissions are taken for the years

- 2006 – 2017 from the national energy statistics prepared by Ministry of Energy & Water (MEW) and National Statistics and Information Authority (NSIA); but this data does only provide the national production, import and/or export. The final supply is taken from UNSD statistics.
- 1990 – 2017 from the UN Statistics Division (UNSD) - Energy Statistics Section.
- 2017 data of 2016 as this data was not available

The vehicle fleet data used for estimating the GHG and non-GHG emissions are taken for the years

- 2006 – 2017 from the Afghanistan Statistical yearbook prepared by National Statistics and Information Authority (NSIA).

As shown in the following figure, the 'apparent' fuel consumption is estimated using a top-down bottom up approach. In Table 135 and Table 136 the estimation of the fuel consumption for the year 2017 provided.

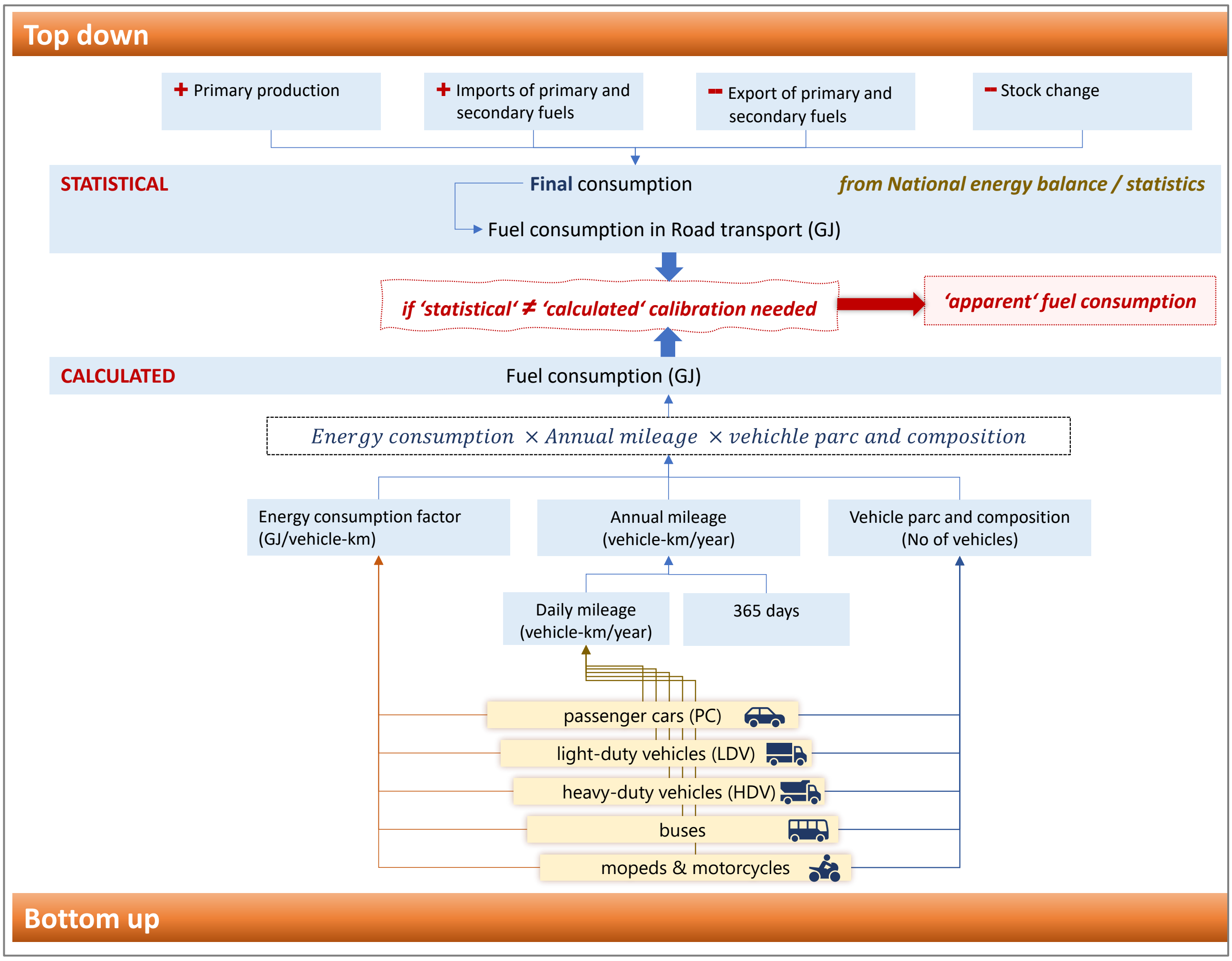


Figure 92 Top-down – Bottom-up approach for estimation of 'apparent' fuel consumption

The total fuel consumption increased by 244.9% in the period 1990 – 2017. From 2005 to 2017 the total fuel consumption increased also significantly by 238.8%.

Table 134 Fuel consumption by fuel type (calculated / based on assumptions) for IPCC sub-category 1.A.3.b Road transport

	Total fuels (incl. biomass)	Liquid fuels				Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
			Diesel	Gasoline	LPG					
	TJ									
1990	51,138	51,138	36,120	15,018	NO	NA	NA	NA	NA	NO
1991	47,495	47,495	33,540	13,955	NO	NA	NA	NA	NA	NO
1992	27,430	27,430	12,900	14,530	NO	NA	NA	NA	NA	NO
1993	26,216	26,216	12,040	14,176	NO	NA	NA	NA	NA	NO
1994	24,996	24,996	11,352	13,644	NO	NA	NA	NA	NA	NO
1995	23,954	23,954	10,664	13,290	NO	NA	NA	NA	NA	NO
1996	27,975	27,975	12,470	15,505	NO	NA	NA	NA	NA	NO
1997	25,578	25,578	11,180	14,398	NO	NA	NA	NA	NA	NO
1998	23,832	23,832	10,320	13,512	NO	NA	NA	NA	NA	NO
1999	13,736	13,736	11,610	2,126	NO	NA	NA	NA	NA	NO
2000	15,065	15,065	11,610	3,455	NO	NA	NA	NA	NA	NO
2001	17,950	17,950	12,900	5,050	NO	NA	NA	NA	NA	NO
2002	17,380	17,380	14,190	3,190	NO	NA	NA	NA	NA	NO
2003	35,415	35,415	15,480	19,935	NO	NA	NA	NA	NA	NO
2004	43,285	43,285	30,121	13,164	NO	NA	NA	NA	NA	NO
2005	52,061	52,061	35,511	16,550	NO	NA	NA	NA	NA	NO
2006	61,943	61,943	41,430	20,513	NO	NA	NA	NA	NA	NO
2007	74,496	74,496	48,521	25,332	643	NA	NA	NA	NA	NO
2008	87,049	87,049	55,612	30,151	1,286	NA	NA	NA	NA	NO
2009	99,602	99,602	62,703	34,971	1,928	NA	NA	NA	NA	NO
2010	108,546	108,546	67,921	38,481	2,144	NA	NA	NA	NA	NO
2011	119,479	119,479	75,515	41,651	2,313	NA	NA	NA	NA	NO
2012	163,341	163,341	102,777	51,820	8,744	NA	NA	NA	NA	NO
2013	170,024	170,024	107,349	53,682	8,993	NA	NA	NA	NA	NO
2014	173,128	173,128	109,605	54,449	9,075	NA	NA	NA	NA	NO
2015	174,735	174,735	110,657	54,966	9,112	NA	NA	NA	NA	NO
2016	176,373	176,373	111,878	55,377	9,118	NA	NA	NA	NA	NO
2017	176,373	176,373	111,878	55,377	9,118	NA	NA	NA	NA	NO
Trend										
1990 - 2017	244.9%	244.9%	209.7%	268.7%	#DIV/0!	-	-	-	-	-
2005 - 2017	238.8%	238.8%	215.1%	234.6%	#DIV/0!	-	-	-	-	-
2012 - 2017	8.0%	8.0%	8.9%	6.9%	4.3%	-	-	-	-	-
2016 - 2017	0.0%		0.0%	0.0%	0.0%					

Table 135 Exemplary calculation of activity data for IPCC sub-category 1.A.3.b Road transport

	Fuel type	Daily mileage	No of days per year used	Annual mileage	Energy consumption factor		Density	Net caloric value	Annual consumption per vehicle	2017		
										Vehicle fleet	Annual fuel consumption of vehicle fleet	
		DM	day	AM	$cons_l$	$cons_g$	ρ	NCV	con_{annual}	no_{veh}	con_{fleet}	
		km/day	No of days	km/year	l/100 km	g/km	kg/l	GJ/kg	tonnes	vehicle	ton	GJ
Formula	-	-	-	DM x day	.	$cons_l$ x ρ	-	-	AM x $cons_g$ x 10^-6	-	con_{annual} x no_{veh}	con_{fleet} x NCV
Total vehicle fleet										**1,906,938**	**6,126,738**	**176,373**
Lorries or HDV	Diesel	60	285	17,100	39.3	331.9	0.8439	43.00	5.68	**315,194**	1,789,133	76,933
Buses			285							**106,947**	450,905	
Buses	Diesel	60	285	17,100	39.3	331.9	0.8439	43.00	5.68	*64,168*	364,237	15,662
Small buses or LDV	Diesel	55	285	15,675	15.1	127.4	0.8439	43.00	2.00	*26,737*	53,405	2,296
Small buses or LDV	Gasoline	55	285	15,675	17.9	132.3	0.7407	44.30	2.07	*16,042*	33,262	1,474
Passenger Cars			285							**1,156,873**	1,578,453	
Passenger Cars	Diesel	50	285	14,250	13.6	115.0	0.8439	43.00	1.64	*231,375*	379,104	16,301
Passenger Cars	Gasoline	50	285	14,250	13.8	102.1	0.7407	44.30	1.45	*694,124*	1,009,767	44,733
Passenger Cars	LPG	50	285	14,250	11.0	57.5	0.5222	47.30	0.82	*231,375*	189,583	8,967
Motorcycle	Gasoline	30	285	8,550	28.4	68.9	0.7407	44.30	0.59	**270,185**	159,130	7,049
Rickshaw	Gasoline	30	285	8,550	28.4	68.9	0.7407	44.30	0.59	**18,820**	11,084	491
Foreigner's Vehicles			285							**38,919**	52,743	
Foreigner's Vehicles	Diesel	50	285	14,250	13.6	115.0	0.8439	43.00	1.64	*9,730*	15,942	686
Foreigner's Vehicles	Gasoline	50	285	14,250	13.8	102.1	0.7407	44.30	1.45	*25,297*	36,801	1,630
Foreigner's Vehicles	LPG	50	285	14,250	11.0	57.5	0.5222	47.30	0.82	*3,892*	3,189	151
Source		Expert judgement			1996 GL, Chap Energy page 1.74		IEA Energy Manual	2006 IPCC GL, Vol. 2		Values in bold: NSIA		

Table 136 Exemplary calculation of CO_2, N_2O and CH_4 emissions for IPCC sub-category 1.A.3.b Road transport

	Fuel type	Net caloric value	2017								
			Vehicle fleet	Annual fuel consumption of vehicle fleet		CO_2 Emission factor	CO_2 emissions	CH_4 Emission factor	CH_4 Emission factor	N_2O emissions	N_2O Emission factor
		NCV	no	con_{fleet}		EF_{CO2}	EMI_{CO2}	EF_{CH4}	EF_{CH4}	EMI_{N2O}	EF_{N2O}
		GJ/kg	vehicle	ton	GJ	kg CO_2/GJ	Gg	kg CO_2/GJ	Gg	kg CO_2/GJ	Gg
Total vehicle fleet			**1,906,938**	**6,126,738**	**176,373**		**12,703,158**		**2,829**		**615**
Lorries or HDV	Diesel	43.00	**315,194**	1,789,133	76,933	74.100	5,700,713	0.0039	300	0.0039	300
Buses			**106,947**	450,905		74.100	1,432,849		119		75
Buses	Diesel	43.00	64,168	364,237	15,662	74.100	1,160,569	0.0039	61	0.0039	61
Small buses or LDV	Diesel	43.00	26,737	53,405	2,296	74.100	170,165	0.0039	9	0.0039	9
Small buses or LDV	Gasoline	44.30	16,042	33,262	1,474	69.300	102,114	0.033	49	0.0032	5
Passenger Cars			**1,156,873**	1,578,453			4,873,747		2,096		209
Passenger Cars	Diesel	43.00	231,375	379,104	16,301	74.100	1,207,938	0.0039	64	0.0039	64
Passenger Cars	Gasoline	44.30	694,124	1,009,767	44,733	69.300	3,099,975	0.033	1,476	0.0032	143
Passenger Cars	LPG	47.30	231,375	189,583	8,967	63.100	565,834	*0.062*	*556*	*0.0002*	*2*
Motorcycle	Gasoline	44.30	**270,185**	159,130	7,049	69.300	488,528	0.033	233	0.0032	23
Rickshaw	Gasoline	44.30	**18,820**	11,084	491	69.300	34,029	0.033	16	0.0032	2
Foreigner's Vehicles			**38,919**	52,743			173,293		66		8
Foreigner's Vehicles	Diesel	43.00	9,730	15,942	686	74.100	50,796	0.0039	3	0.0039	3
Foreigner's Vehicles	Gasoline	44.30	25,297	36,801	1,630	69.300	112,979	0.033	54	0.0032	5
Foreigner's Vehicles	LPG	47.30	3,892	3,189	151	63.100	9,518	0.062	9.4	0.0002	0
Source		2006 IPCC GL, Vol. 2, Chap. 1				2006 IPCC GL, Vol. 2, Chap. 3, Table 3.2.1	2006 IPCC GL, Vol. 2, Chap. 3, Equation 3.2.1	2006 IPCC GL, Vol. 2, Chap. 3, Table 3.2.2	2006 IPCC GL, Vol. 2, Chap. 3, Equation 3.2.3	2006 IPCC GL, Vol. 2, Chap. 3, Table 3.2.2	2006 IPCC GL, Vol. 2, Chap. 3, Equation 3.2.3

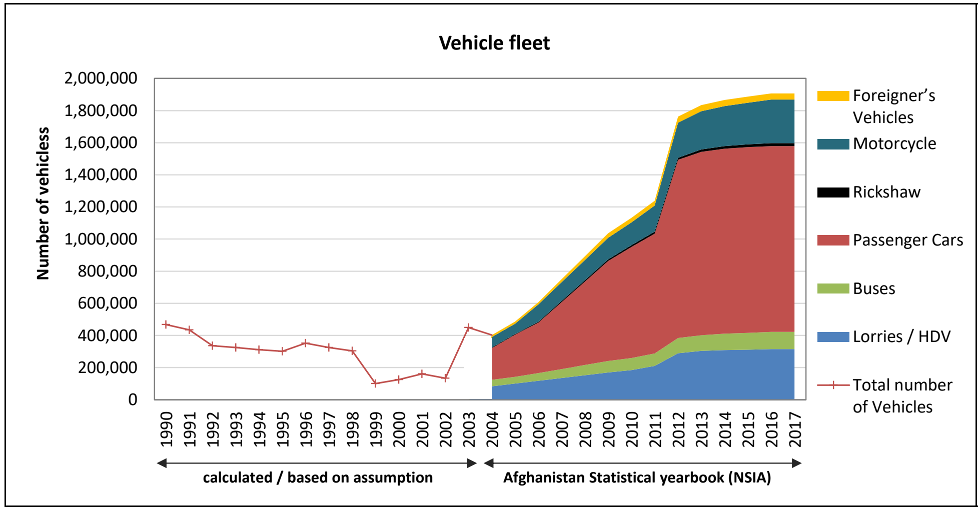


Figure 93 Vehicle fleet of Afghanistan: 1990 – 2003 calculated; 2004 – 2017 NSIA

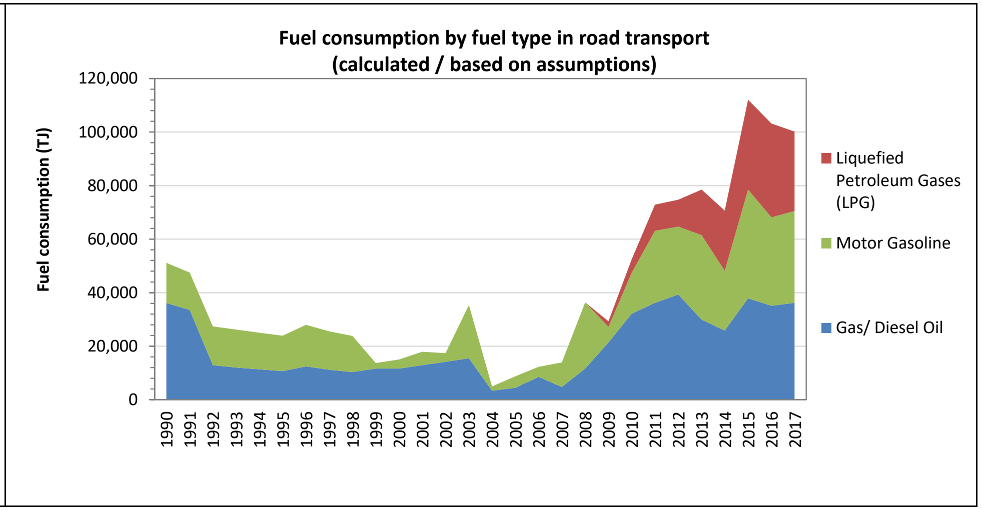


Figure 94 Fuel consumption per fuel type of road transport of Afghanistan (calculated / based on assumptions)

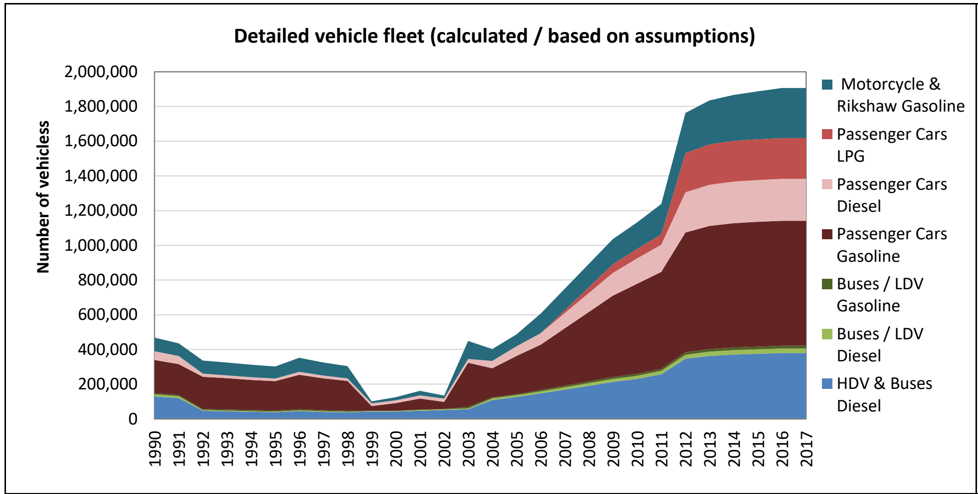


Figure 95 Detailed Vehicle fleet of Afghanistan (calculated / based on assumptions)

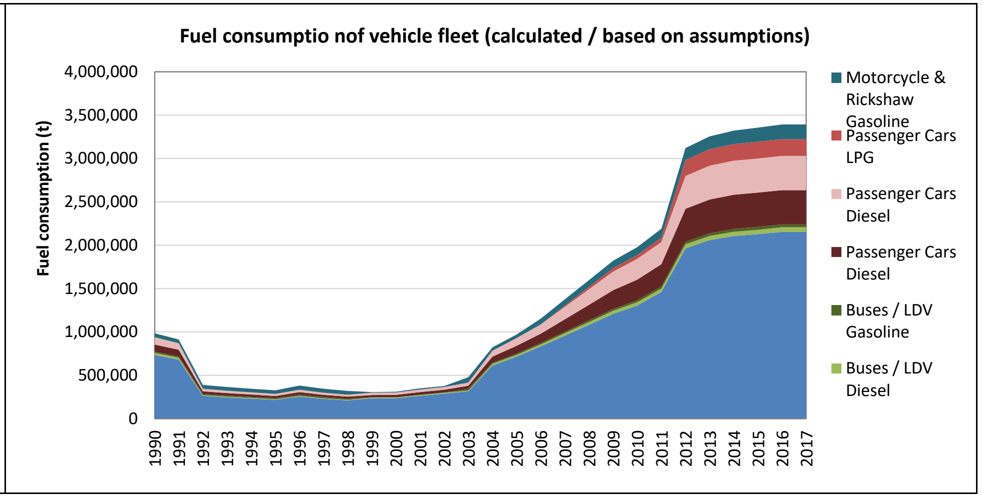


Figure 96 Fuel consumption of vehicle fleet of Afghanistan (calculated / based on assumptions)

Table 137 Vehicle fleet – Lorries, buses, motorcycles and rickshaws – for IPCC sub-category 1.A.3.b Road transport

Activity data 1.A.3.b	Total Vehicles	Lorries / HDV		Buses		Buses		Buses LDV		Buses LDV		Motorcycle		Rickshaw	
	All fuels	Diesel		All fuels		Diesel		Diesel		Gasoline		Gasoline		Gasoline	
	number	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*
1990	468,414	99,981	$EJ_{split\ in\ vehicle\ fleet}$	48,319	$EJ_{split\ in\ vehicle\ fleet}$	29,205	$EJ_{split\ in\ vehicle\ fleet}$	12,169	$EJ_{split\ in\ vehicle\ fleet}$	6,946	$EJ_{split\ in\ vehicle\ fleet}$	74,643	$EJ_{split\ in\ vehicle\ fleet}$	3,813	$EJ_{split\ in\ vehicle\ fleet}$
1991	435,131	92,839		44,872		27,119		11,299		6,454		69,358		3,543	
1992	336,233	35,707		21,497		10,430		4,346		6,720		72,221		3,689	
1993	325,139	33,327		20,348		9,735		4,056		6,556		70,459		3,599	
1994	311,691	31,422		19,314		9,179		3,824		6,311		67,817		3,464	
1995	301,510	29,518		18,362		8,622		3,593		6,147		66,056		3,374	
1996	351,913	34,517		21,455		10,083		4,201		7,171		77,065		3,936	
1997	324,658	30,946		19,465		9,040		3,766		6,659		71,560		3,655	
1998	303,767	28,566		18,070		8,344		3,477		6,249		67,157		3,430	
1999	100,789	32,137		14,282		9,387		3,911		983		10,569		540	
2000	125,282	32,137		14,897		9,387		3,911		1,598		17,174		877	
2001	161,517	35,707		17,112		10,430		4,346		2,336		25,101		1,282	
2002	134,072	39,278		17,729		11,473		4,781		1,475		15,853		810	
2003	449,527	42,849		26,952		12,516		5,215		9,220		99,083		5,061	
2004	402,409	83,374	*NSIA*	40,590	*NSIA*	24,354	$EJ_{split\ by\ fuel\ type}$	10,148	$EJ_{split\ by\ fuel\ type}$	6,089	$EJ_{split\ by\ fuel\ type}$	65,430	*NSIA*	3,342	*NSIA*
2005	486,141	100,883		41,731		25,039		10,433		6,260		64,817		3,342	
2006	606,944	117,460		48,513		29,108		12,128		7,277		108,282		5,228	
2007	749,971	134,886	*IP*	56,202	*IP*	33,721		14,051		8,430		117,053	*IP*	6,936	*IP*
2008	892,998	152,311		63,892		38,335		15,973		9,584		125,825		8,643	

Activity data 1.A.3.b	Total Vehicles	Lorries / HDV		Buses		Buses		Buses LDV		Buses LDV		Motorcycle		Rickshaw	
	All fuels	Diesel		All fuels		Diesel		Diesel		Gasoline		Gasoline		Gasoline	
	number	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*
2009	1,036,025	169,737	NSIA	71,581	NSIA	42,949		17,895		10,737		134,596	NSIA	10,351	NSIA
2010	1,132,288	184,799		74,834		44,900		18,709		11,225		141,833		10,647	
2011	1,238,332	210,601		77,946		46,768		19,487		11,692		163,152		11,635	
2012	1,762,357	288,936		95,027		57,016		23,757		14,254		218,708		12,646	
2013	1,834,315	303,708		98,070		58,842		24,518		14,711		238,396		14,849	
2014	1,866,283	309,540		102,124		61,274		25,531		15,319		248,832		15,803	
2015	1,887,263	311,905		104,543		62,726		26,136		15,681		259,237		16,738	
2016	1,906,938	315,194		106,947		64,168		26,737		16,042		270,185		18,820	
2017	1,906,938	315,194	*Const*	106,947	*Const*	64,168	*Const*	26,737	*Const*	16,042	*Const*	270,185	*Const*	18,820	*Const*
Trend															
1990 - 2017	*307.1%*	*215.3%*		*121.3%*		*119.7%*		*119.7%*		*131.0%*		*262.0%*		*393.6%*	
2005 - 2017	*292.3%*	*212.4%*		*156.3%*		*156.3%*		*156.3%*		*156.3%*		*316.8%*		*463.1%*	
1990 - 2017	*8.2%*	*9.1%*		*12.5%*		*12.5%*		*12.5%*		*12.5%*		*23.5%*		*48.8%*	
Remarks	*NSIA*	*NSIA - Table 10-1:Land Transportation*[82]				*$EJ_{split\ in\ fuel\ type}$*		*Expert judgement: vehicle fleet split in fuel type*						*LDV - Light-duty vehicle/ Light-commercial vehicles*	
	IP	*Interpolation*				*$EJ_{split\ in\ vehicle\ fleet}$*		*Expert judgement: Fuel consumption split in vehicle fleet*							
	Const	*Value as of 2016*												*HDV Heavy-duty vehicle*	

[82] *NSIA (different years): Afghanistan Statistical Yearbook - Table 10-1:Land Transportation. Kabul.*

Table 138 Vehicle fleet – Passenger Cars (PC), Foreigner’s Vehicles – for IPCC sub-category 1.A.3.b Road transport

Activity data 1.A.3.b	Total Vehicles	Passenger Cars (PC)		Passenger Cars (PC)		Passenger Cars (PC)		Passenger Cars (PC)		Foreigner’s Vehicles		Foreigner’s Vehicles		Foreigner’s Vehicles		Foreigner’s Vehicles	
	All fuels	All fuels		Diesel		Gasoline		LPG		All fuels		Diesel		Gasoline		LPG	
	number	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*
1990	468,414	227,556	*$EJ_{\text{split in vehicle fleet}}$*	47,355	*$EJ_{\text{split in vehicle fleet}}$*	180,200	*$EJ_{\text{split in vehicle fleet}}$*	NO	*$EJ_{\text{split in vehicle fleet}}$*	14,103	*$EJ_{\text{split in vehicle fleet}}$*	2,935	*$EJ_{\text{split in vehicle fleet}}$*	11,168	*$EJ_{\text{split in vehicle fleet}}$*	NO	*$EJ_{\text{split in vehicle fleet}}$*
1991	435,131	211,416		43,973		167,443		NO		13,103		2,725		10,377		NO	
1992	336,233	191,266		16,913		174,353		NO		11,854		1,048		10,806		NO	
1993	325,139	185,886		15,785		170,101		NO		11,520		978		10,542		NO	
1994	311,691	178,605		14,883		163,722		NO		11,069		922		10,147		NO	
1995	301,510	173,451		13,981		159,469		NO		10,750		866		9,883		NO	
1996	351,913	202,397		16,349		186,048		NO		12,544		1,013		11,530		NO	
1997	324,658	187,416		14,658		172,759		NO		11,615		908		10,707		NO	
1998	303,767	175,657		13,530		162,127		NO		10,886		839		10,048		NO	
1999	100,789	40,737		15,221		25,515		NO		2,525		943		1,581		NO	
2000	125,282	56,683		15,221		41,462		NO		3,513		943		2,570		NO	
2001	161,517	77,511		16,913		60,598		NO		4,804		1,048		3,756		NO	
2002	134,072	56,877		18,604		38,273		NO		3,525		1,153		2,372		NO	
2003	449,527	259,499		20,295		239,204		NO		16,083		1,258		14,825		NO	
2004	402,409	197,449	*NSIA*	39,490	*NSIA*	157,959	*$EJ_{\text{split by fuel type}}$*	NO	*$EJ_{\text{split by fuel type}}$*	12,237	*$EJ_{\text{split by fuel type}}$*	2,447	*NSIA*	9,790	*NSIA*	NO	*NSIA*
2005	486,141	262,700		52,540		210,160		NO		12,668		2,534		10,134		NO	
2006	606,944	314,165		62,833		251,332		NO		13,296		2,659		10,637		NO	
2007	749,971	416,756	*IP*	83,351	*IP*	316,820		16,585		18,138		4,091	*IP*	14,047	*IP*	NO	*IP*
2008	892,998	519,346		103,869		382,307		33,170		22,981		5,524		17,457		NO	

Activity data 1.A.3.b	Total Vehicles	Passenger Cars (PC)		Passenger Cars (PC)		Passenger Cars (PC)		Passenger Cars (PC)		Foreigner's Vehicles		Foreigner's Vehicles		Foreigner's Vehicles		Foreigner's Vehicles	
	All fuels	All fuels		Diesel		Gasoline		LPG		All fuels		Diesel		Gasoline		LPG	
	number	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*	number	*source*
2009	1,036,025	621,937	NSIA	124,387	NSIA	447,795		49,755		27,823		6,956	NSIA	20,867	NSIA	NO	NSIA
2010	1,132,288	691,573		138,315		497,933		55,326		28,602		7,151		21,452		NO	
2011	1,238,332	745,875		149,175		537,030		59,670		29,123		7,281		21,842		NO	
2012	1,762,357	1,109,146		221,829		665,488		221,829		37,894		9,474		24,631		3,789	
2013	1,834,315	1,141,023		228,205		684,614		228,205		38,269		9,567		24,875		3,827	
2014	1,866,283	1,151,531		230,306		690,919		230,306		38,453		9,613		24,994		3,845	
2015	1,887,263	1,156,215		231,243		693,729		231,243		38,622		9,656		25,104		3,862	
2016	1,906,938	1,156,873		231,375		694,124		231,375		38,919		9,730		25,297		3,892	
2017	1,906,938	1,156,873	*Const*	231,375	*Const*	694,124	*Const*	231,375	*Const*	38,919	*Const*	9,730	*Const*	25,297	*Const*	3,892	*Const*
Trend																	
1990 - 2017	*307.1%*	*408.4%*		*388.6%*		*285.2%*		*NA*		*176.0%*		*231.5%*		*126.5%*		*NA*	
2005 - 2017	*292.3%*	*340.4%*		*340.4%*		*230.3%*		*NA*		*207.2%*		*284.0%*		*149.6%*		*NA*	
1990 - 2017	*8.2%*	*4.3%*		*4.3%*		*4.3%*		*4.3%*		*2.7%*		*2.7%*		*2.7%*		*2.7%*	

Remarks	*NSIA*	*NSIA - Table 10-1:Land Transportation*[83]		$EJ_{split\ in\ fuel\ type}$	*Expert judgement: vehicle fleet split in fuel type*
	IP	*Interpolation*		$EJ_{split\ in\ vehicle\ fleet}$	*Expert judgement: Fuel consumption split in vehicle fleet*
	Const	*Value as of 2016*			

[83] *NSIA (different years): Afghanistan Statistical Yearbook - Table 10-1:Land Transportation. Kabul.*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic metres. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.3.a. *Road transport and International Aviation*.

Table 139 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.3.b. Road transport

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Gas/ Diesel Oil	liquid	43.00	D	**2006 IPCC Guidelines, Vol. 2, Chap. 1, Table 1.2** Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
Motor Gasoline	liquid	44.30	D	
Liquefied Petroleum Gases (LPG)	liquid	47.30	D	
Note: D Default CS Country specific PS Plant specific				

3.2.7.2.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 140 GHG Emission factor TIER 1 for IPCC sub-category 1.A.3.b. Road transport

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	**2006 IPCC Guidelines Vol. 2, Chap. 3 (3.2.1.2)**
Gas/ Diesel Oil	liquid	74,100	D	-	-	-	-	**TABLE 3.2.1** CO_2 emission factors (page 3.16)
Motor Gasoline		69,300	D	-	-	-	-	
LPG		63,100	D	-	-	-	-	
Gas/ Diesel Oil	liquid	-	-	3.9	D	3.9	D	**TABLE 3.2.2** CO_2 emission factors (page 3.21)
Motor Gasoline		-	-	33	D	3.2	D	
LPG		-	-	62	D	0.2	D	
Note: D Default CS Country specific PS Plant specific IEF Implied emission factor								

Default emission factors for air pollutant were taken from the EMEP/EEA air pollutant emission inventory Guidebook 2016 and are presented in the following table.

Table 141 Non-GHG Emission factor for IPCC sub-category 1.A.3.b Road transport

	Fuel	Fuel type	NOx (g/kg fuel)		CO (g/kg fuel)		NMVOC (g/kg fuel)		SO_2 (g/kg fuel)		Source
			EF	type	EF	type	EF	type	EF	type	EMEP/EEA Guidebook 2016, Part B, Vol 1 - 1A, chap. 1.A.3.b
PC	Motor Gasoline	liquid	8.73	D	84.70	D	10.50	D			**Table 3-5** & **Table 3-6** Tier 1 emission factors for NFR 1.A.3.b.i - 1.A.3.b.iv: Road transport (page. 22 - 23)
	Gas/ Diesel Oil		12.96		3.33	D	0.70	D			
	Liquefied Petroleum Gases		15.20		84.70	D	13.64	D			
LCV	Motor Gasoline	liquid	13.22		152.30	D	14.59	D			
	Gas/ Diesel Oil		14.91		7.40	D	1.54	D			
	Liquefied Petroleum Gases					D		D			
HDV	Motor Gasoline	liquid	33.37		7.58	D	1.92	D			
	Gas/ Diesel Oil		13.00		5.70	D	0.26	D			
	Liquefied Petroleum Gases					D		D			
Two Wheel	Motor Gasoline	liquid	6.64		497.70	D	131.40	D			
	Gas/ Diesel Oil					D		D			
	Liquefied Petroleum Gases					D		D			

Note:

D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.7.2.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.3.b *Road transport* are presented in the following table.

Table 142 Uncertainty for IPCC sub-category 1.A.3.b Road transport.

Uncertainty	Liquid fuels			Reference
	CO_2	CH_4	N_2O	
Activity data (AD)	50%	50%	50%	2006 IPCC GL, Vol. 2, Chap. 3 (3.6.1.7)
Emission factor (EF)	2%	100%	20%	
Combined Uncertainty (U)	50%	112%	54%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.2.7.2.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data, interpolation and documented assumption
  - consistent use of vehicle fleet data, interpolation and documented assumption
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.7.2.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category 1.A.3.b *Road transport*.

Table 143 Recalculations done since SNC in IPCC sub-category 1.A.3.b Road transport

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.3.b	Fuel consumption data (activity data) was revised due to • revised activity data • consideration of imported fuels (reported by importers)(UNSD)	AD	Accuracy
1.A.3.b	use of default NCV of 2006 IPCC Guidelines	AD	Comparability
1.A.3.b	use of default EF of 2006 IPCC Guidelines	EF	Comparability
1.A.3.b	application of 2006 IPCC Guidelines	method	Comparability

3.2.7.2.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 144 Planned improvements for IPCC sub-category 1.A.3.b Road transport

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.3.b	Survey on fuel consumption totals (gasoline, gas/diesel oil/ Fuel oil /LPG Aviation gasoline consumption, Jet Fuel consumption, *T one oil* etc.) and additives (grease, motor oil, etc.): • annual amount of fuel consumption by fuel type • country specific Net Caloric Value (NCV) for imported fuels ⇒ conversion from mass unit to energy unit (unit EF is kg /TJ) • Carbon content (%) of gas/diesel oil, residual fuel oil, natural gas etc. for preparing country specific emission factor (CS EF) ⇒ **CS** $\mathbf{EF_{CO2}}$ [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	AD	Completeness Accuracy Transparency	high
	vehicle kilometer data • annual mileage • passenger kilometers • freight kilometers		Completeness Accuracy Transparency	high
	Road vehicle categories and relevant Legislation/ Technology classes • Passenger Cars • Light Commercial Vehicles (LDV) • Heavy-Duty Vehicles (HDV) • Mopeds and Motorcycles		Completeness Accuracy Transparency	high
1.A.3.b	Cross-check of national and international data sources and feedback to UNSD	AD	Completeness Consistency Transparency	medium
1.A.3.b	Time-series of fuel consumption ⇒ completing time series and gap filling for some years	AD	Consistency Completeness	High
1.A.3.b	Estimation of CO_2 and non-CO_2 emissions as well as non-GHG emission from road transport with a tool like HBEFA[84], ARTEMIS[85], COPERT[86], MOVES[87] and PARAMICS[88] models • Estimation of emission of fuel according to energy statistics • Estimation of emission of smuggled fuels Estimation of emissions from evaporation	AD	Completeness Accuracy Transparency	High
1.A.3.b	Survey on national / regional vehicle data – agriculture, construction, household, and relevant technology classes • Operation hours • Utilization rate	AD	Completeness Accuracy Transparency	High

[84] INFRAS (2019): Handbook Emission Factors for Road Transport (HBEFA): The Handbook Emission Factors for Road Transport (HBEFA) provides emission factors for all current vehicle categories (PC, LDV, HGV, urban buses, coaches and motorcycles), each divided into different categories, for a wide variety of traffic situations. Emission factors for all regulated and the most important non-regulated pollutants as well as fuel consumption and CO_2 are included. Available (25 May 2019) at: https://www.hbefa.net/e/index.html

[85] State Secretariat for Education and Research and Innovation SERI (2009): ARTEMIS: Assessment of road transport emission models and inventory systems. Bern, Swiss. Available (25 May 2019) at: https://trl.co.uk/reports/PPR350

[86] COPERT is the EU standard vehicle emissions calculator. It uses vehicle population, mileage, speed and other data such as ambient temperature and calculates emissions and energy consumption for a specific country or region. Available (25 May 2019) at: https://www.emisia.com/utilities/copert/

[87] USEPA (2018): MOtor Vehicle Emission Simulator (MOVES): EPA's MOtor Vehicle Emission Simulator (MOVES) is a state-of-the-science emission modeling system that estimates emissions for mobile sources at the national, county, and project level for criteria air pollutants, greenhouse gases, and air toxics. Available (25 May 2019) at: https://www.epa.gov/moves

[88] Paramics Microsimulation (2019): Paramics Discovery 22. Edinburgh. Available (25 May 2019) at: https://www.paramics.co.uk/en/paramics-discovery/article/paramics-discovery-22

3.2.7.3 Railways (IPCC category 1.A.3.c)

This section describes GHG emissions resulting from fuel combustion in Railways (IPCC category 1.A.3.c). Currently there is a 75 km long track between Hairatan and Mazar-e-Sharif. Relevant fuel consumption is not provided in the energy balance. It is assumed, that in category 1.A.3 Transport the consumption of all fuels except kerosene (jet fuel type) were allocated to sub-category 1.A.3.b *Road transport*. Thus, all emissions were estimated.

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.3.c	IE	IE	NO	NE	NO	NO	IE	IE	NO	NE	NO	NO	IE	IE	NO	NE	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE	1.A.3.c liquid fuels	The amount of fuel consumption is included in 1.A.3.b Road transport.
IE	1.A.3.c solid	The amount of fuel consumption is included in 1.A.2.m *Other*.

3.2.7.4 Water-borne Navigation (IPCC category 1.A.3.d)

This section describes GHG emissions resulting from fuel combustion in Water-borne Navigation (IPCC category 1.A.3.d). The use of inland waterways is limited to the Amu Darya and the Panj River, where Shir Khan Bandar, the only river port, is located.[89]

However, relevant fuel consumption is not provided in the energy balance. It is assumed, that in category 1.A.3 Transport the consumption of all fuels except kerosene (jet fuel type) were allocated to sub-category 1.A.3.b *Road transport*. Thus, all emissions were estimated.

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.3.d	IE	NA	NO	NO	NO	NO	IE	NA	NO	NO	NO	NO	IE	NA	NO	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE	1.A.3.d liquid fuels	The amount of fuel consumption is included in 1.A.3.b Road transport.

[89] Source: ASIAN DEVELOPMENT BANK (2017): Afghanistan Transport Sector Master Plan Update (2017–2036). Philippines. Available (18.12.2018) at https://www.adb.org/documents/afg-transport-plan-update-2017-2036

3.2.7.5 Other Transportation (IPCC category 1.A.3.e)

This section describes GHG emissions resulting from fuel combustion in Other Transportation (IPCC category 1.A.3.e). Relevant fuel consumption, especially from off-road, is not provided in the energy balance. It is assumed, that in category 1.A.3 Transport the consumption of all fuels except kerosene (jet fuel type) were allocated to sub-category 1.A.3.b *Road transport*. Thus, all emissions were estimated.

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.3.e.i	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO
1.A.3.e.ii	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE 1.A.3.e liquid fuels The amount of fuel consumption is included in 1.A.3.b Road transport.

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3.2.8 Other Sectors (IPCC category 1.A.4)

Category 1.A.4 *Other sectors* comprise emissions from stationary fuel combustion in the small combustion sector including combustion for the generation of electricity and heat for own use in these sectors. It also includes emissions from mobile sources in households and gardening as well as from agriculture and forestry.

- 1.A.4.a Commercial/Institutional
- 1.A.4.b Residential
- 1.A.4.c Agriculture/Forestry/Fishing/Fish Farms
  - 1.A.4.c.i Stationary
  - 1.A.4.c.ii Off-road Vehicles and Other Machinery
  - 1.A.4.c.iii Fishing (mobile combustion)

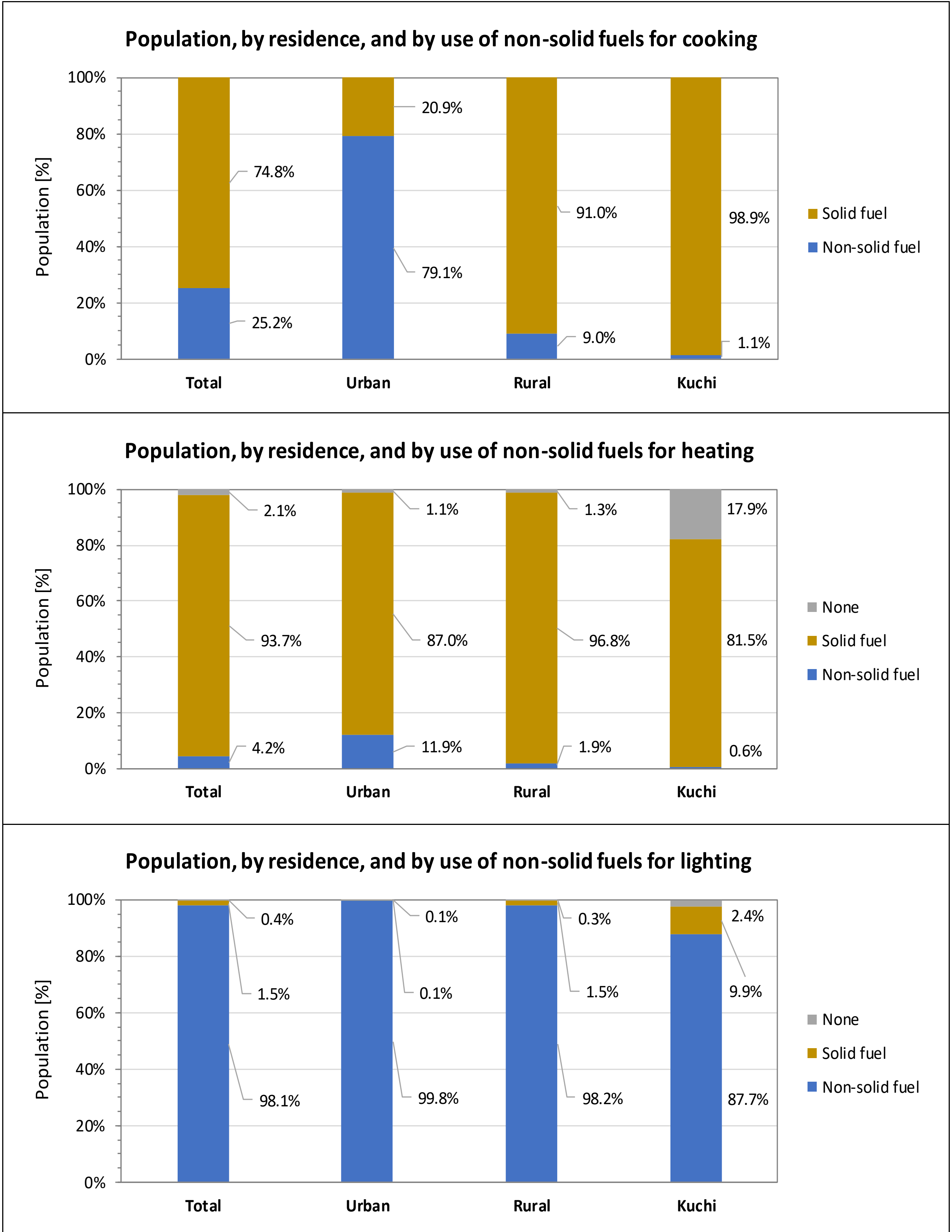
The national energy statistics currently do not provide information regarding the use of fuels in the different IPCC subcategories. Therefore, all emissions are reported under IPCC subcategory 1.A.4.b *Residential*.

3.2.8.1 Country specific introduction

The use of solid fuels, such as wood, charcoal, crop residues or animal dung but also coal, is very common for cooking and heating in Afghanistan. According to the ALCS 2016/17 the use of solid fuels amounts to 76% for cooking and to 95% for heating. Lighting is derived almost completely from electricity and gas. Furthermore, a substantial proportion of Kuchi people continues to have no access to heating in wintertime (17.9%). The following figure presents the percentages of the population using solid and non-solid fuels, or no fuels at all, at national level and disaggregated by urban, rural and for the Kuchi population. It follows that most people rely on wood or diesel fuel. In addition, in many rural areas, kerosene and dried cakes of animal dung are common fuels. Also stated in the ALCS 2016/17 that fuel used by households for lighting purposes is generally from clean sources, cooking and heating fuels have aroused increasing interest over the past twenty-five years, mainly due to increased population and non-availability of adequate connection to the electricity grid. The high demand on wood as fuel has led to extensive deforestation.

The burning of biomass such as wood and charcoal does not contribute to the CO_2 emissions as these emissions are excluded from the Total National GHG emissions, but the production of charcoal has a significant contribution to the Total National CH_4 emission. Moreover, cooking with biomass fuels on open fires also causes significant health problems.

The following table presents the percentages of the population using solid and non-solid fuels, or no fuels at all, at national level and disaggregated by urban, rural and for the Kuchi population, based on data of the ALCS 2016/17.



Remark: In this context the terms solid fuels and non-solid fuels are used differently to IPCC!

- Solid fuels include biomass fuels, such as bushes, wood, charcoal, crops or other agricultural waste, animal dung and coal.
- Non-solid fuels include electricity and gas.

Figure 97 Population using solid and non-solid fuels, or no fuels at all, at national level and disaggregated by urban, rural and for the Kuchi population in 2016

3.2.8.2 Commercial/Institutional (IPCC category 1.A.4.a)

3.2.8.2.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	Liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.4.a	IE	IE	IE	IE	NO	IE	IE	IE	IE	IE	NO	IE	IE	IE	IE	IE	NO	IE
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE	1.A.4.a liquid	All fuels are reported under 1.A.4.b as the energy balance does not provide any split.
IE	1.A.4.b gaseous	Natural gas is used in one power plant which is mainly serving the Northern Fertilizer Power Plant (NFPP). Therefore, these activity data and emissions are included in IPCC sub-category 1.A.2.c *Chemicals*.
IE	1.A.4.b solid	The amount of fuel consumption is included in 1.A.2.m *Other*.
IE	1.A.4.a Other fossil fuels	All fuels are reported under 1.A.4.b as the energy balance does not provide any split.
IE	1.A.4.a liquid	All fuels are reported under 1.A.4.b as the energy balance does not provide any split.

3.2.8.2.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 145 Planned improvements for IPCC sub-category 1.A.4.a Commercial/Institutional

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.4.a	See Table 154 Planned improvements for IPCC sub-category 1.A.4.b Residentials.			

3.2.8.3 Residential (IPCC category 1.A.4.b)

3.2.8.3.1 Source category description

GHG emissions/ removals Estimated	CO_2						CH_4						N_2O					
	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.4.b	✓	IE	IE	✓	NO	✓	✓	IE	IE	✓	NO	✓	✓	IE	IE	✓	NO	✓
Key Category	LA 1990, 2017 TA	LA 1990, 2017 TA	-	-	-	-	-	-	-	LA 1990, 2017 TA	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE	1.A.4.b gaseous	Natural gas is used in one power plant which is mainly serving the Northern Fertilizer Power Plant (NFPP). Therefore, these activity data and emissions are included in IPCC sub-category 1.A.2.c *Chemicals*.
IE	1.A.4.b solid	The amount of fuel consumption is included in 1.A.2.m *Other*.
NE	1.A.4.b Other fossil fuel	The amount of fuel consumption is not known/available.

This section describes GHG emissions resulting from fuel combustion activities for cooking, heating and lightning in households. As the national energy statistic currently does not provide information regarding the use of fuels in the different IPCC subcategories *Commercial/Institutional*, *Residential*, *Agriculture/Forestry/ Fishing/Fish Farms*, all GHG emissions are here reported.

An overview of the GHG emission from fuel combustion in IPCC sub-category 1.A.4.a *residentials* is provided in the following figure and table.

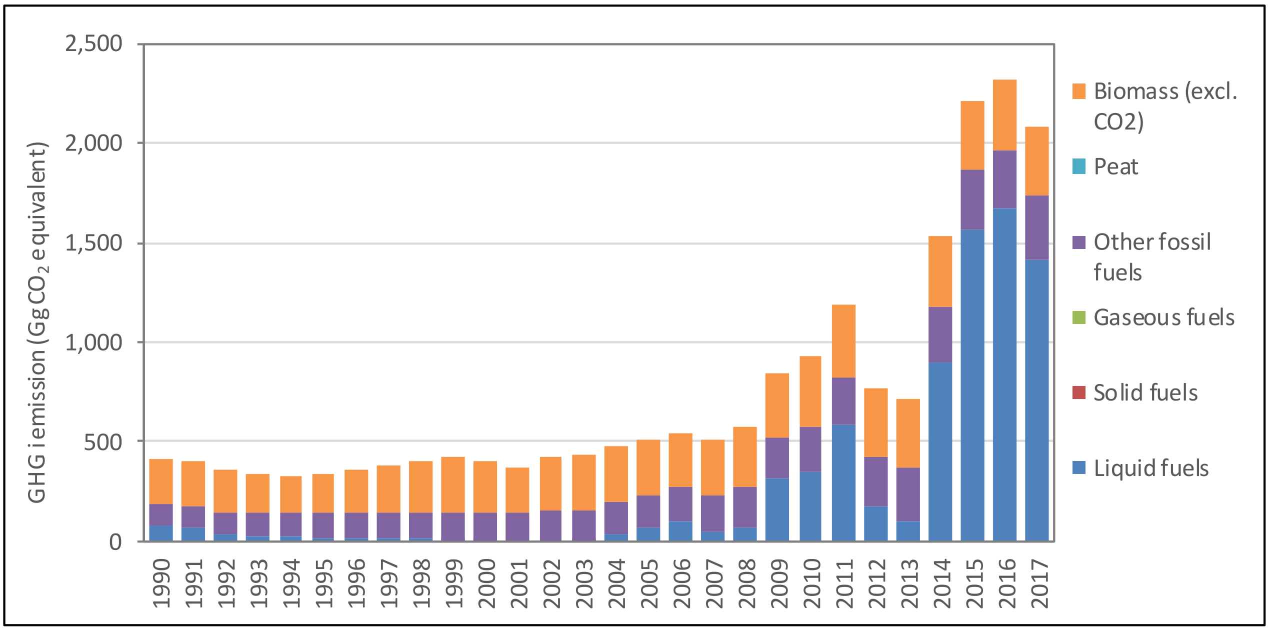


Figure 98 Emissions from IPCC sub-category 1.A.4.b Residential

The share in total GHG emissions from sector 1.A.4.b is 2.3% for the year 1990, 2.2% for the year 2005, and 4.8% for the year 2017. In the period 1990 to 2017 GHG emissions from sub-category 1.A.4.b increased by 412% from 407.66 Gg CO_2 eq in 1990 to 2,085.95 Gg CO_2 eq in 2017. In the period 2005 to 2017 GHG emissions from sub-category 1.A.4.b increased by 313%.

The fluctuation of the GHG emissions are mainly due to increased electricity consumption for heating coupled with non-availability of hydropower

- in winter;
- during drought and seasonal conditions;
- increased demand in rural areas by generators.
- In the period 1990 to 2017 ***CO_2 emissions from Biomass combustion for Energy Production***, which are not included in the Total national GHG emissions, increased by 59.7% from 2,648.29 Gg CO_2 eq in 1990 to 4,230.35 Gg CO_2 eq in 2017. In the period 2005 to 2017 GHG emissions from sub-category 1.A.4.b increased by 26%.

In the following figure and table, a comparison of GHG emissions from *residentials* and *CO_2 emissions from Biomass combustion for Energy Production*, also mainly occurring from *residentials* is provided.

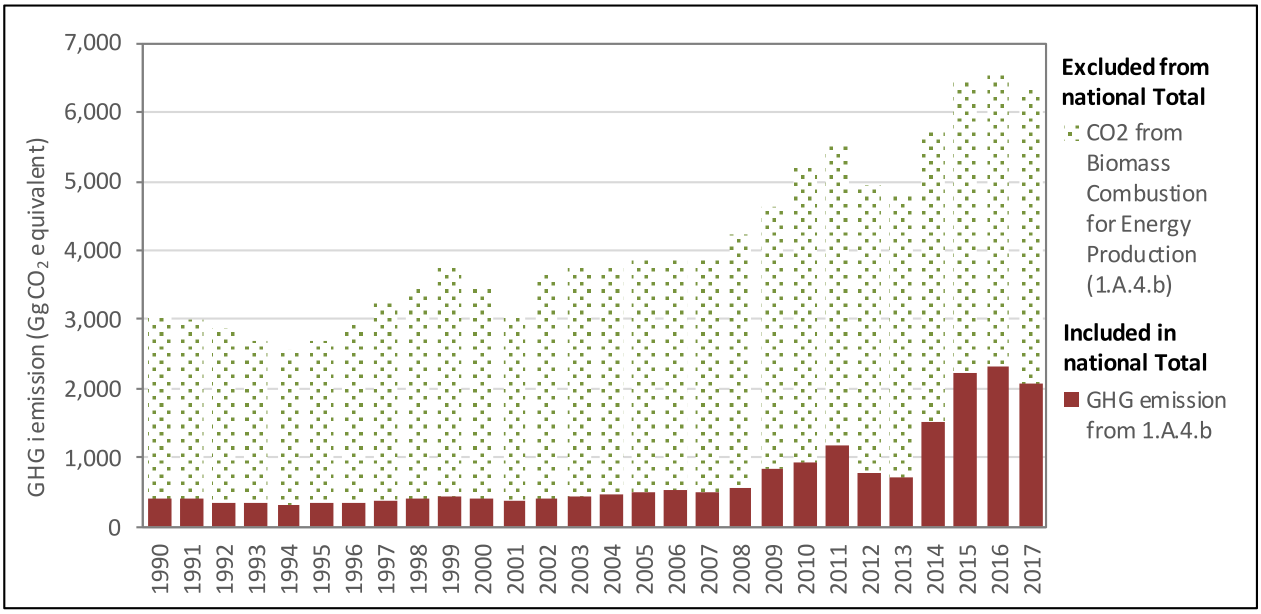


Figure 99 Comparison of GHG Emissions from IPCC sub-category 1.A.4.b and CO_2 emissions from Biomass combustion for Energy Production

Table 146 Emissions from IPCC sub-category 1.A.4.b Residential

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	407.66	173.37	202.52	0.20	2,648.29
1991	397.76	167.70	198.90	0.17	2,597.81
1992	355.83	132.94	192.82	0.08	2,518.25
1993	339.04	130.81	180.23	0.06	2,351.30
1994	327.10	128.86	171.68	0.05	2,238.68
1995	338.89	130.34	180.64	0.04	2,359.50

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1996	360.93	130.20	199.85	0.03	2,619.17
1997	381.13	130.17	217.38	0.02	2,856.65
1998	401.16	133.49	231.84	0.02	3,050.84
1999	425.90	130.06	256.22	0.02	3,382.56
2000	401.89	131.40	234.41	0.00	3,091.05
2001	368.19	133.29	203.75	NO	2,683.40
2002	420.05	136.20	246.02	0.00	3,248.29
2003	430.98	139.48	252.66	0.00	3,338.11
2004	475.70	184.06	252.76	0.09	3,334.95
2005	504.99	212.84	253.21	0.16	3,341.17
2006	545.19	253.42	252.86	0.23	3,326.77
2007	507.32	213.11	255.09	0.10	3,350.35
2008	575.82	254.34	278.61	0.17	3,653.77
2009	838.79	504.40	289.42	0.73	3,778.08
2010	933.67	553.87	328.85	0.48	4,295.94
2011	1188.83	803.76	333.47	0.50	4,343.47
2012	771.67	402.23	320.13	0.24	4,168.42
2013	711.79	346.74	316.39	0.21	4,111.53
2014	1,530.47	1,156.39	324.16	0.53	4,185.72
2015	2,213.58	1,833.02	329.77	0.77	4,234.56
2016	2,319.42	1,940.11	328.71	0.85	4,218.94
2017	2,085.95	1,704.65	330.37	0.89	4,230.35
Trend 1990 - 2017	412%	883%	63%	356%	59.7%
Trend 2005 - 2017	313%	812%	30%	441%	26%
Trend 2016 - 2017	-10%	-12%	1%	5%	0.3%

3.2.8.3.2 Methodological issues

3.2.8.3.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[90] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

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

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O

[90] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG}} = \sum_{\boldsymbol{fuel}} \boldsymbol{emissions_{\mathbf{GHG,\,fuel}}}$$

For estimating the air pollutants emissions (NO_x, CO, NMVOC, SO_2) the Tier 1 approach[91] of the EMEP/EEA air pollutant emission inventory guidebook 2016 has been applied:

Equation: Air pollutant emissions from stationary combustion

$$\boldsymbol{Emissions_{pollutant} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{pollutant,\,fuel}}$$

Where:

Emissions $_{pollutant}$	= emissions of a given pollutant by type of fuel (kg pollutant)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{pollutant,\ fuel}$	= default emission factor of a given pollutant by type of fuel (g $_{pollutant}$/GJ).
Pollutant	= NOx, CO, NMVOC, SO_2

3.2.8.3.2.2 Choice of activity data

The following fuels are used for electricity production, cooking and heating:

Gaseous fuels	Natural gas
Solid fuels:	Other bituminous coal
Liquid fuels:	• Liquefied Petroleum Gases (LPG) • Other Kerosene
Other fossil fuel	Waste
Biomass	• Fuel wood • dung

Natural gas is used in the power plant which is mainly serving the Northern Fertilizer Power Plant (NFPP) in Mazar-e-Sharif. The Northern Fertilizer Power Plant (NFPP) is an auto-producer which is also provides small amount of natural gas directly to households. As the principal activity is fertilizer production, the activity data and emissions are included in IPCC sub-category 1.A.2.c *Chemicals* and IPCC sub-category *2.B.1 Ammonia Production.*

The **solid fuel** consumption (coal) in IPCC sub-category 1.A.4.a Residentials is not well known. The energy balance does not provide any information. Therefore, the whole amount of solid fuel (coal) consumed is included in 1.A.2.m Other.

The consumption of **liquid fuel, Other Kerosene** and **Liquefied Petroleum Gases (LPG)** used for estimating the GHG and non-GHG emissions are taken for the years

- 2006 - 2013 from the national energy statistics prepared by Ministry of Energy & Water (MEW) and National Statistics and Information Authority (NSIA); but this data does only provide the national production, import and/or export. The final supply is taken from UNSD statistics.
- 1990 – 2005 from the UN Statistics Division (UNSD) - Energy Statistics Section.

[91] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, 1.A.2 Manufacturing industries and construction (combustion), sub-chapter 3.2.1 Tier 1 default approach.

The amount of **Other fossil fuel**, waste (non-biomass/non-renewable fraction), used for fuel consumption is not well known. However, in general, it is forbidden to burn waste it, but it happens. An annual amount of waste burned by households for heating purpose is provided in chapter 7 Waste - Country-specific issues (7.1.2). relevant assumptions and underlying information and data is provided in the sub-chapters

- 7.1.2.27.1.2.37.1.2.5 Waste collection and waste disposal routes: Identification of waste treatments and allocation the waste to the waste treatments
- 7.1.2.3 Compilation of activity data on Municipal Solid Waste (MSW) generation per year
- 7.1.2.5 Allocation of the Municipal Solid Waste (MSW) to various waste treatments

The fuelwood and charcoal **(biomass)** burned by households for heating and cooking purpose is taken for all years from the UN Statistics Division (UNSD) - Energy Statistics Section. These data are consistent with data reported by FAO statistics.

The dung cakes **(biomass)** burned by households for heating and cooking purpose are estimated based on expert judgement.

- The livestock data are taken from national statistics and FAO. The data used are consistent with data used in sector Agriculture and the complete activity data are provided in Chapter 5.
- The share of dung burned per livestock category is based on expert judgement and information provided in Table 5 (column 2) of MILBRANDT & OVEREND (2011): Assessment of Biomass Resources in Afghanistan.[92]
- The information on dung production in ton per livestock and year was taken from MILBRANDT & OVEREND (2011), Table 5. The data provided for Afghanistan were adopted from TATLIDIL et al. (2009): Animal Manure as One of the Main Biogas Production Resources: Case of Turkey.[93] In the following table are the relevant information for the year 2017 provided.
- The moisture content and loss of the weight through drying is based on expert judgement and information provided in
  - NRCS (2008): Agricultural Waste Management Field Handbook;[94]
  - UN (2018): International Recommendations for Energy Statistics (IRES): Energy values of selected animal and vegetal wastes (Table 8).[95]
- The net calorific value (NCV) of dung of 13.6 MJ/kg was taken from UN (2018): International Recommendations for Energy Statistics (IRES): Energy values of selected animal and vegetal wastes (Table 8).[95]

[92] MILBRANDT, A. & OVEREND, R. (2011): Assessment of Biomass Resources in Afghanistan; Technical Report NREL/TP-6A20-49358, January 2011. Prepared under Task No. WF3N.7001. Available (25 March 2019) on https://www.nrel.gov/docs/fy11osti/49358.pdf

[93] TATLIDIL, F.; BAYRAMOGLU, Z.; AKTURK, D. (2009). "Animal Manure as One of the Main Biogas Production Resources: Case of Turkey," Journal of Animal and Veterinary Advances, Volume 8, Issue 12, pages 2,473–2,476. Available (25 March 2019) on https://www.researchgate.net/publication/294234615_Animal_Manure_as_One_of_the_Main_Biogas_Production_Resources_Case_of_Turkey

[94] USDA NATURAL RESOURCES CONSERVATION SERVICE (NRCS)(2008): Agricultural Waste Management Field Handbook; Chapter 4 Agricultural Waste. Part 651. 210–VI–AWMFH, March 2008. Available (25 March 2019) on https://www.researchgate.net/publication/294234615_Animal_Manure_as_One_of_the_Main_Biogas_Production_Resources_Case_of_Turkey

[95] United Nation (UN) (2018): International Recommendations for Energy Statistics (IRES): ST/ESA/STAT/SER.M/93. Available (25 November 2018) on https://unstats.un.org/unsd/energy/ires/IRES-web.pdf

Table 147 Activity data and parameter for estimating amount of dung cakes burned in 2017

IPCC code	IPCC category	No. of animals	share of dung burned	No. of animals where dung burned	Dung production	Moisture reduction	Dung cake (fuel)
			%		ton/unit/year	%	tonnes
3.A.1	Dairy Cattle	3,578,531	50%	1,789,266	3.6	13%	837,376
3.A.1	Non-Dairy Cattle	1,655,869	53%	877,611	3.6	15%	473,910
3.A.2	Diary Sheep	7,139,219	30%	2,141,766	0.7	20%	299,847
3.A.2	Non-Diary Sheep	6,125,981	30%	1,837,794	0.7	20%	257,291
3.A.4	Other – Dairy Goats	2,637,305	30%	791,192	0.7	20%	110,767
3.A.4	Other – Non-Dairy Goats	4,810,695	30%	1,443,209	0.7	20%	202,049
3.A.4	Other – Dairy Camels	21,963	9%	1,977	3.6	15%	1,067
3.A.4	Other – Non-Dairy Camels	148,537	9%	13,368	3.6	15%	7,219
3.A.4	Other – Horses	171,200	50%	85,600	3.6	85%	261,936
3.A.4	Other – Mules and Asses	1,497,000	50%	748,500	2.9	15%	325,598
	TOTAL						**2,777,060**
	Reference	NSIA & FAO	Expert judgement based on MILBRANDT & OVEREND (2011)		MILBRANDT & OVEREND (2011)	Expert judgement based on NRCS (2008) and IRES (2018)	

The total fuel consumption increased by 136% in the period 1990 – 2017. From 2005 to 2017 the total fuel consumption increased by 89%. From 2016 to 2017 the total fuel consumption decreased by -5.5% due to increasing demand of fuel for cooking and heating.

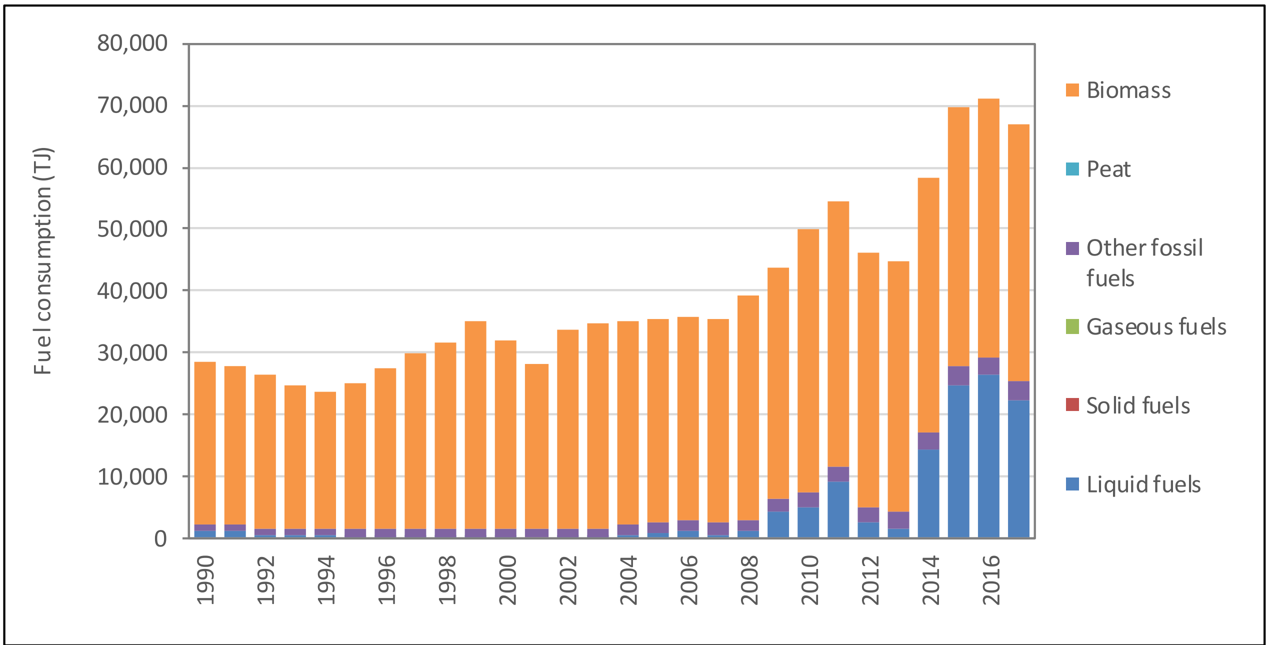


Figure 100 Activity data for IPCC sub-category 1.A.4.b Other Sectors

Table 148 Activity data for IPCC sub-category 1.A.4.b Residentials

Activity data 1.A.4.b	Total fuels (incl. biomass)	Liquid fuels			Solid fuels	Gaseous fuels	Other fossil fuels	Biomass			
		Total	Other Kerosene	LPG	Total	Total	Total	Total	Fuelwood	Charcoal	Dung
Years	TJ										
1990	28,445	1,095	1,095	NO	IE	IE	1,006	26,344	5	1,150	25,189
1991	27,848	964	964	NO	IE	IE	1,050	25,835	5	1,190	24,639
1992	26,561	438	438	NO	IE	IE	1,096	25,027	5	1,287	23,735
1993	24,838	350	350	NO	IE	IE	1,143	23,344	6	1,404	21,934
1994	23,657	263	263	NO	IE	IE	1,193	22,202	6	1,536	20,659
1995	24,856	219	219	NO	IE	IE	1,244	23,393	7	1,677	21,709
1996	27,425	175	175	NO	IE	IE	1,278	25,972	7	1,827	24,138
1997	29,772	131	131	NO	IE	IE	1,313	28,328	8	1,983	26,337
1998	31,737	131	131	NO	IE	IE	1,350	30,256	8	2,094	28,154
1999	34,992	88	88	NO	IE	IE	1,348	33,556	8	2,234	31,314
2000	32,058	9	9	NO	IE	IE	1,426	30,623	9	2,384	28,231
2001	27,990	NO	NO	NO	IE	IE	1,453	26,537	9	2,471	24,057
2002	33,661	4	4	NO	IE	IE	1,482	32,175	9	2,560	29,605
2003	34,585	13	13	NO	IE	IE	1,510	33,062	9	2,653	30,399
2004	35,126	526	526	NO	IE	IE	1,582	33,018	10	2,750	30,259
2005	35,558	876	876	NO	IE	IE	1,613	33,069	10	2,850	30,209
2006	35,921	1,270	1,270	NO	IE	IE	1,737	32,914	10	2,937	29,967
2007	35,572	569	569	NO	IE	IE	1,864	33,139	10	3,028	30,101
2008	39,120	964	964	NO	IE	IE	1,995	36,162	10	3,121	33,031
2009	43,711	4,187	4,073	114	IE	IE	2,131	37,393	10	3,217	34,166
2010	49,926	5,095	2,190	2,905	IE	IE	2,271	42,560	11	3,318	39,232
2011	54,399	8,975	1,577	7,398	IE	IE	2,400	43,024	11	3,412	39,601
2012	46,290	2,497	1,139	1,358	IE	IE	2,532	41,262	11	3,510	37,741
2013	44,769	1,423	1,139	284	IE	IE	2,666	40,681	11	3,611	37,059
2014	58,337	14,124	745	13,380	IE	IE	2,802	41,410	11	3,715	37,684
2015	69,558	24,731	254	24,477	IE	IE	2,941	41,886	11	3,822	38,052
2016	71,040	26,346	416	25,930	IE	IE	2,978	41,716	11	3,936	37,768
2017	67,117	22,116	1,568	20,548	IE	IE	3,183	41,818	12	4,038	37,768
Trend											
1990 - 2017	*136%*	*1920%*	*43%*	*NA*	*-*	*-*	*216%*	*59%*	*128%*	*251%*	*50%*
2005 - 2017	*89%*	*2425%*	*79%*	*NA*	*-*	*-*	*85%*	*26%*	*18%*	*42%*	*25%*
2016 - 2017	*-6%*	*-16%*	*277%*	*-21%*	*-*	*-*	*7%*	*0%*	*2%*	*3%*	*0%*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic metres. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.4.b *Residentials*.

Table 149 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.4.b Residentials

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Other Kerosene	liquid	43.8	D	**2006 IPCC Guidelines, Vol. 2, Chap. 1, Table 1.2** Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
LPG	liquid	47.3	D	
Municipal Wastes (non-biomass fraction)	Other fossil fuel	10.0	D	
Fuelwood	biomass	15.6	D	
Charcoal	biomass	29.5	D	
Dung	biomass	13.6	D	UN (2018): International Recommendations for Energy Statistics (IRES): Energy values of selected animal and vegetal wastes (Table 8)

Note:
D Default CS Country specific PS Plant specific

3.2.8.3.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 150 GHG Emission factor TIER 1 for IPCC sub-category 1.A.4.b Residentials

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	**2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)**
Other Kerosene	liquid	71 900	D	10	D	0.6	D	**Table 2.5** Default emission factors for manufacturing industries and construction (page 2.22ff)
LPG	liquid	63 100	D	5	D	0.1	D	
Municipal Wastes (non-biomass fraction)	Other fossil fuel	91 700	D	300	D	4	D	
Fuelwood	biomass	112 000	D	300	D	4	D	
Charcoal	biomass	112 000	D	200	D	1	D	
Dung	biomass	100 000	D	300	D	4	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

Default emission factors for air pollutant were taken from the EMEP/EEA air pollutant emission inventory Guidebook 2016 and are presented in the following table.

Table 151 Non-GHG Emission factor for IPCC sub-category 1.A.4.b Residentials

Fuel	Fuel type	NOx (g/GJ) or (kg/Mg waste)		CO (g/GJ) or (kg/Mg waste)		NMVOC (g/GJ) or (kg/Mg waste)		SO_2 (g/GJ) or (kg/Mg waste)		Source
		EF	type	EF	type	EF	type	EF	type	EMEP/EEA Guidebook 2016, Part B, Vol 1 - 1A, chap. 1.A.4 Small combustion
Other Kerosene	liquid	51	D	57	D	0.69	D	70	D	**Table 3-5** Tier 1 emission factors for NFR source category 1.A.4.b, using liquid fuels (page. 36)
LPG	liquid	51	D	57	D	0.69	D	70	D	
Municipal Wastes (non-biomass fraction)	Other fossil fuel	1.8	D	0.7	D	0.02	D	1.7	D	**Table 3-7** Tier 1 emission factors for NFR source category 1.A.4.b, using biomass (page. 37)
Fuelwood	biomass	80	D	4000	D	600	D	11	D	
Charcoal	biomass	80	D	4000	D	600	D	11	D	
Dung	biomass	80	D	4000	D	600	D	11	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.8.3.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.4.b *Residentials* are presented in the following table.

Table 152 Uncertainty for IPCC sub-category 1.A.4.b Residentials.

Uncertainty	Liquid fuels			Other fossil fuels			Biomass			Reference
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	2006 IPCC GL, Vol. 2, Chap. 2 (2.4.2)
Activity data (AD)	15%	15%	15%	100%	100%	100%	45%	45%	45%	Table 2.15
Emission factor (EF)	3%			3%			3%			Table 2.13
		100%			100%			100%		Table 2.12
			20%			20%			20%	Table 2.14
Combined Uncertainty (U)	15%	101%	25%	10%	141%	102%	45%	110%	49%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.2.8.3.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.8.3.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category 1.A.4.b *Residentials*.

Table 153 Recalculations done since SNC in IPCC sub-category 1.A.4.b Residentials.

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.4.b	Fuel consumption data (activity data) was revised due to revised activity data	AD	Accuracy
1.A.4.b	Waste and dung for fuel consumption data (activity data) was included	AD	Completeness
1.A.4.b	use of default NCV of 2006 IPCC Guidelines	AD	Comparability
1.A.4.b	use of default EF of 2006 IPCC Guidelines	EF	Comparability
1.A.4.b	application of 2006 IPCC Guidelines	method	Comparability

3.2.8.3.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 154 Planned improvements for IPCC sub-category 1.A.4.b Residentials.

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.4	Split of fuel consumption to different sub-categories	EF	Transparency	medium
	Survey on fuel used (solid, natural gas, liquid fuels, other fossil fuels, biomass, etc.): • annual amount of fuel consumption by fuel type • combustion technologies (stoves, boilers, etc.)		Transparency Accuracy	high
1.A.4.b	Survey on fuel used and relevant characteristics: • Waste – biomass fraction / non-biomass fraction • Dung cake	AD	Completeness	high
1.A.4.b	Cross-check of national and international data sources and feedback to UNSD	AD	Completeness	medium
1.A.4.b	Time-series of fuel consumption	AD	Consistency Completeness	high
1.A.4.b	Country specific Net Caloric Value (NCV) for imported fuels: diesel and residual fuel ⇒ conversion from mass unit to energy unit (unit EF is kg /TJ)	AD EF	Accuracy Transparency	medium
1.A.4.b	Carbon content (%) of liquid fuels, waste and biomass etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox) / (NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	medium
1.A.4.b	Sulphur content in used fuel for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{SO2}$** [g/GJ] = (S [%] • 20000) / (NCV [GJ/t])	EF non-GHG	Accuracy Transparency	medium

3.2.8.4 Agriculture/Forestry/Fishing/Fish Farms (IPCC category 1.A.4.c)

3.2.8.4.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	Liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.4.c.i	IE	IE	IE	IE	NO	IE	IE	IE	IE	IE	NO	IE	IE	IE	IE	IE	NO	IE
1.A.4.c.ii	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO
1.A.4.c.iii	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year); TA – Trend Assessment																		

Use of notation key

IE	1.A.4.c.i	All fuels are reported under 1.A.4.b as the energy balance does not provide any split.
IE	1.A.4.c.ii	All fuels are reported under 1.A.4.b as the energy balance does not provide any split.
IE	1.A.4.c.iii	All fuels are reported under 1.A.4.b as the energy balance does not provide any split.

3.2.8.4.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 155 Planned improvements for IPCC sub-category 1.A.4.c Agriculture/Forestry/Fishing/Fish Farms

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.4.a	• See Table 154 Planned improvements for IPCC sub-category 1.A.4.b Residentials.			

3.2.9 Non-Specified (IPCC category 1.A.5)

This section describes GHG emissions resulting from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the military in the country and delivered to the military of other countries that are not engaged in multilateral operations.

IPCC code	Description		Occurrent		Not occurrent (NO)
			Estimated	Not estimated (NE)	
1.A.5.a	Stationary	Emissions from fuel combustion in stationary sources that are not specified elsewhere.		✓	
1.A.5.b	Mobile	Emissions from vehicles and other machinery, marine and aviation (not included in 1 A 4 c ii or elsewhere).			
1.A.5.b.i	Mobile (aviation component)	All remaining aviation emissions from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the country's military as well as fuel delivered within that country but used by the militaries of other countries that are not engaged in multilateral operations.		✓	
1.A.5.b.ii	Mobile (water-borne component)	All remaining water-borne emissions from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the country's military as well as fuel delivered within that country but used by the militaries of other countries that are not engaged in multilateral operations.		✓	
1.A.5.b.iii	Mobile (Other)	All remaining emissions from mobile sources not included elsewhere.		✓	
1.A.5.c	Multilateral Operations (Memo item[96])	Emissions from fuels used in multilateral operations pursuant to the Charter of the United Nations. Include emissions from fuel delivered to the military in the country and delivered to the military of other countries.		✓	

[96] Not included in National Total

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	Liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.5.a	NE	NE	NE	NE	NO	NE	NE	NE	NE	NE	NO	NE	NE	NE	NE	NE	NO	NE
1.A.5.b	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO
1.A.5.b.i	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO
1.A.5.b.ii	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO
1.A.5.b.iii	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO
1.A.5.c	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment

The national energy statistics currently do not provide information regarding the use of fuels in the different IPCC subcategories.

3.3 Fugitive emissions from fuels (IPCC category 1.B)

This section describes GHG emissions resulting from the extraction, processing and delivery of fossil fuels to the point of final use, also known as fugitive emissions. Both GHG emissions from surface and underground mining activities are accounted for.

Methane (CH_4) is produced naturally in the process of coal formation and thus is considered the most important fugitive emission for coal mining and handling.

Furthermore, methane and CO_2 emitted during mining from breakage of coal and associated strata and leakage from the pit floor and highwall.

Fugitive emissions of CH_4 and CO_2 from the production, transmission and distribution of oil and natural gas are estimated based on the quantity reported in the energy statistics.

3.3.1 Solid Fuels (IPCC category 1.B.1)

This section describes GHG emissions resulting from the fugitive CH_4 emissions from coal mining and handling activities in underground and surface mines.

IPCC code	Description
1.B.1.a	Coal mining and handling
1.B.1.a.i	Underground mines
1.B.1.a.i.1	Mining
1.B.1.a.i.2	Post-mining seam gas emissions
1.B.1.a.i.3	Abandoned underground mines
1.B.1.a.i.4	Flaring of drained methane or conversion of methane to CO_2
1.B.1.a.ii	Surface mines
1.B.1.a.ii.1	Mining
1.B.1.a.ii.2	Post-mining seam gas emissions
1.B.1.b	Uncontrolled combustion and burning coal dumps
1.B.1.c	Solid fuel transformation

3.3.1.1 Coal mining and handling (IPCC category 1.B.1.a)

3.3.1.1.1 Source category description

GHG emissions/removals	CO_2	CH_4	N_2O
Estimated	NA	✓	NA
Key Category	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential			

Afghanistan has moderate to potentially abundant coal resources. The country is rich of coking coal reserves. The coal deposits are primarily located within a Jurassic belt from the northern provinces of Takhar and Badakhshan through the center of the country and towards the west in Herat, according to the Ministry of Mines and Petroleum. However, most deposits are relatively deep or currently inaccessible, and reserves are largely undeveloped. The main factors limiting widespread use of coal are rugged terrain, lack of transportation networks, and the absence of industrial infrastructure. In addition, a considerable amount of the mining activities is said to be illegal, which might lead to uncontrolled combustion and burning of coal dumps.

In 2017, coal mining was responsible for about 0,1 % of GHG emissions in form of fugitive emissions. Compared to 1990, CH_4 emissions from underground and surfaced mining increased by 14% to attain the level of 1.14 Gg CH_4 in 2017. In In the period 2005 - 2017 the coal production lead to an increase of CH_4 emissions by 14% as t. Emissions from the mining are expected to grow as the country develops.

Table 156 CH_4 emissions from Solid fuels (IPCC sub-category 1.B.1.)

Due to technical mistake, only some emissions are included in the current Total National GHG Inventory (current submission). Anyway, the correct information is already presented in this table. With the next submission all emissions will be included in the Total National GHG inventory.

Year	CH_4 emission						
	1.B.1 Solid Fuels (Total)	1.B.1.a Coal Mining and Handling				1.B.1.b Solid Fuel Transformation	
		i. Underground Mines		ii. Surface Mines			
		Mining	Post-mining	Mining	Post-mining	Coking coal	Charcoal
	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	1.31	1.14	0.16	0.01	0.00	IE	IE
1991	1.17	1.02	0.14	0.01	0.00	IE	IE
1992	0.10	0.09	0.01	0.00	0.00	IE	IE
1993	0.09	0.08	0.01	0.00	0.00	IE	IE
1994	0.07	0.07	0.01	0.00	0.00	IE	IE
1995	0.06	0.05	0.01	0.00	0.00	IE	IE
1996	0.04	0.03	0.00	0.00	0.00	IE	IE
1997	0.02	0.02	0.00	0.00	0.00	IE	IE
1998	0.02	0.02	0.00	0.00	0.00	IE	IE
1999	0.01	0.01	0.00	0.00	0.00	IE	IE
2000	0.01	0.01	0.00	0.00	0.00	IE	IE
2001	0.32	0.28	0.04	0.00	0.00	IE	IE
2002	0.26	0.23	0.03	0.00	0.00	IE	IE
2003	0.44	0.38	0.05	0.00	0.00	IE	IE
2004	0.42	0.37	0.05	0.00	0.00	IE	IE
2005	0.41	0.36	0.05	0.00	0.00	IE	IE
2006	0.44	0.38	0.05	0.00	0.00	IE	IE
2007	3.03	2.64	0.37	0.02	0.00	IE	IE
2008	6.23	5.43	0.75	0.04	0.00	IE	IE
2009	9.02	7.87	1.09	0.06	0.00	IE	IE
2010	18.42	16.06	2.23	0.12	0.01	IE	IE
2011	15.44	13.46	1.87	0.10	0.01	IE	IE
2012	16.77	14.62	2.03	0.11	0.01	IE	IE
2013	18.89	16.47	2.29	0.12	0.01	IE	IE
2014	16.99	14.81	2.06	0.11	0.01	IE	IE
2015	17.23	15.03	2.09	0.11	0.01	IE	IE
2016	21.14	18.43	2.56	0.14	0.01	IE	IE
2017	27.28	23.79	3.30	0.18	0.01	IE	IE
Trend							
1990 - 2017	1987%	1987%	1987%	1987%	1987%	-	-
2005 - 2017	6541%	6541%	6541%	6541%	6541%	-	-
2016 - 2017	29%	29%	29%	29%	29%	-	-

3.3.1.1.2 Methodological issues

3.3.1.1.2.1 Choice of methods

For estimating the GHG emissions based on coal production activity data from underground coal mining and post-mining, the 2006 IPCC Guidelines Tier 1 method has been applied *(2006 IPCC GL, Vol. 2, Chap. 4)*:

Equation 4.1.1: Estimating emissions from underground coal mines for Tier 1 and Tier 2

$$GHG\ emissions = Raw\ coal\ production \times Emission\ \mathrm{Factor} \times Units\ conversion\ factor$$

Where:

GHG Emissions = emissions of a given GHG by type
Raw coal production = amount of coal produced (tonnes)
Emission factor = default emission factor by type of mining ($m^3\ tonne^{-1}$)
Unites conversion factor = conversion factor by type of gas (Gg/m^3)

3.3.1.1.2.2 Choice of activity data

Data on national hard coal production are taken for the years

- 1990 – 2007 from UN Statistics Division (UNSD) - Energy Statistics Section;
- 2008 –2017 from National Statistics and Information Authority (NSIA)

As no information about the different types of coal mines were available, the quantities of coal mined are split in surface mining (10%) and underground mining (90%) based on an expert judgement.

Table 157 National Hard coal production

Years	Hard coal production					
	Total		Underground Mines		Surface Mines	
	Gg	Source	Gg	Source	Gg	Source
1990	105.00	UN Statistics Division (UNSD)	94.50	expert judgement	10.50	expert judgement
1991	94.00		84.60		9.40	
1992	8.00		7.20		0.80	
1993	7.00		6.30		0.70	
1994	6.00		5.40		0.60	
1995	5.00		4.50		0.50	
1996	3.00		2.70		0.30	
1997	2.00		1.80		0.20	
1998	2.00		1.80		0.20	
1999	1.00		0.90		0.10	
2000	1.00		0.90		0.10	
2001	26.00		23.40		2.60	
2002	21.00		18.90		2.10	
2003	35.00		31.50		3.50	
2004	34.00		30.60		3.40	
2005	33.00		29.70		3.30	
2006	35.00		31.50		3.50	
2007	243.00		218.70		24.30	

Years	Hard coal production					
	Total		Underground Mines		Surface Mines	
	Gg	Source	Gg	Source	Gg	Source
2008	500.10	National Statistics and Information Authority (NSIA)	450.09		50.01	
2009	724.90		652.41		72.49	
2010	1,479.60		1,331.64		147.96	
2011	1,239.90		1,115.91		123.99	
2012	1,347.00		1,212.30		134.70	
2013	1,517.40		1,365.66		151.74	
2014	1,364.80		1,228.32		136.48	
2015	1,384.40		1,245.96		138.44	
2016	1,698.20		1,528.38		169.82	
2017	2,191.40		1,972.26		219.14	
Trend						
1990 - 2017	1987%		1987%		1987%	
2005 - 2017	6541%		6541%		6541%	
2016 - 2017	29%		29%		29%	

3.3.1.1.2.3 Choice of emission factors

As country specific information was insufficient to derive CS factors, the following default emissions factors were applied:

Coal mining	Default EF (m^3/t)	Source
Underground mines		
Emission factors (CH_4) Mining	18	2006 IPCC GL, Vol. 2, Chap.4, p. 4.12
Emission factors (CH_4) Post-Mining	2.5	
Surface mines		
Emission factors (CH_4) Mining	1.2	2006 IPCC GL, Vol. 2, Chap.4, p. 4.19
Emission factors (CH_4) Post-Mining	0.1	

3.3.1.2 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.2.m *Other* are presented in the following table.

Table 158 Uncertainty for IPCC sub-category 1.B.1 CH_4 emissions from Solid fuels

Uncertainty	CH_4				Reference
	Surface Mining		Underground mining		2006 IPCC GL, Vol. 2, Chap. 4 (4.1.4.6 & 4.3.6)
	Mining	Post-mining	Mining	Post-mining	
Activity data (AD)	10%		10%		Chap. 4.1.3.6 (p. 4.16)
Emission factor (EF)	200%		300%		Table 4.1.2 (p. 4.15)
		300%		300%	Table 4.1.4 (p. 4.20)
Combined Uncertainty (U)	200%	300%	300%	300%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.3.1.3 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed:

- ⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.
- ⇒ time series consistency - plausibility checks of dips and jumps.

3.3.1.4 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 2.A.1 Cement production.

Table 159 Recalculations done since submission 2017 IPCC sub-category 1.B.1 CH_4 emissions from Solid fuels

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
2.A.2	No recalculation as this source is estimated the first time	method	Accuracy

3.3.1.5 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 160 Planned improvements for IPCC sub-category 1.A.2.m Other

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.B.1.a	Correction of technical mistake	AD	accuracy	high
1.B.1.a	Survey on mining activities: underground and surface mining	AD	accuracy	medium
1.B.1.a	Time-series of national coal production and cross-check of national and international data sources (e.g. UNSD, BGS, USGS) and feedback to UNSD;	AD	Consistency Completeness	high
1.B.1.a.i.2, 1.B.1.a.i.2	Survey on post-mining activities (surface and underground mining)	AD	accuracy	medium
1.B.1.a.i.3 & 1.B.1.a.i.4	Survey on Abandoned underground mines and on flaring of drained methane	AD	accuracy	medium
1.B.1.b	Uncontrolled combustion and burning coal dumps	AD	accuracy	medium

3.3.2 Oil and Natural Gas (IPCC category 1.B.2)

This section describes the fugitive GHG emissions from oil and gas systems except contributions from fuel combustion. Oil and natural gas systems consists of infrastructure required to produce, collect, process or refine and deliver natural gas and petroleum products to market. The scope of the inventory includes all relevant processes from the well head, or oil and gas source, to the final sales point to the consumer.

IPCC code	Description	Occurrent		Not occurrent
		Estimated	Not estimated	
1.B.2.a	Oil	✓		
1.B.2.a.i	Venting	✓		
1.B.2.a.ii	Flaring	✓		
1.B.2.a.iii	All Other			
1.B.2.a.iii.1	Exploration		✓	
1.B.2.a.iii.2	Production and Upgrading	✓		
1.B.2.a.iii.3	Transport	✓		
1.B.2.a.iii.4	Refining		✓	
1.B.2.a.iii.5	Distribution of oil products			✓
1.B.2.a.iii.6	Other			
1.B.2.b	Natural Gas			
1.B.2.b.i	Venting		✓	
1.B.2.b.ii	Flaring	✓		
1.B.2.b.iii	All Other			
1.B.2.b.iii.1	Exploration	IE		
1.B.2.b.iii.2	Production	✓		
1.B.2.b.iii.3	Processing	✓		

IPCC code	Description	Occurrent		Not occurrent
		Estimated	Not estimated	
1.B.2.b.iii.4	Transmission and Storage	✓		
1.B.2.b.iii.5	Distribution			✓
1.B.2.b.iii.6	Other		✓	

3.3.2.1 Oil and natural gas systems (IPCC category 1.B.2.)

3.3.2.1.1 Source category description

GHG emissions/removals	Oil			Natural gas		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Estimated	✓	✓	✓	✓	✓	✓
Key Category	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential						

Table 161 Fugitive CH_4 emissions (Gg) from Oil and natural gas systems (IPCC sub-category 1.B.2)

Year	1. B. 2. a. Oil				1. B. 2. b. Natural Gas				1. B. 2. c. Venting and Flaring			
									1. B. 2. c. 1 Venting		1. B. 2. c. 2 Flaring	
	i. Exploration	ii. Production	iii. Transport	iv. Refining / Storage	ii. Production	iii. Processing	iv. Transmission	v. Distribution	i. Oil	ii. Gas	i. Oil	ii. Gas
1988	0.0000	0.0000	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000	NA	0.0000	0.0000
1989	0.0000	0.0000	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000	NA	0.0000	0.0000
1991	0.0000	0.0147	0.0000	NA	0.0002	0.1651	0.1324	0.0000	0.0008	NA	0.0000	0.0005
1996	0.0000	0.0168	0.0000	NA	0.0001	0.1303	0.1045	0.0000	0.0009	NA	0.0000	0.0004
2001	0.0000	0.0188	0.0000	NA	0.0001	0.0886	0.0710	0.0000	0.0010	NA	0.0000	0.0003
2006	0.0000	0.0188	0.0000	NA	0.0002	0.1355	0.1086	0.0000	0.0010	NA	0.0000	0.0004
2011	0.0000	0.0424	0.0001	NA	0.0001	0.1275	0.1022	0.0000	0.0022	NA	0.0000	0.0004
2012	0.0000	0.0470	0.0001	NA	0.0001	0.1266	0.1015	0.0000	0.0025	NA	0.0000	0.0004
2013	0.0000	0.0670	0.0001	NA	0.0001	0.1221	0.0979	0.0000	0.0035	NA	0.0000	0.0004
2014	0.0000	0.0623	0.0001	NA	0.0001	0.1121	0.0899	0.0000	0.0033	NA	0.0000	0.0003
2015	0.0000	0.0563	0.0001	NA	0.0001	0.1155	0.0926	0.0000	0.0030	NA	0.0000	0.0004
2016	0.0000	0.0509	0.0001	NA	0.0001	0.1306	0.1047	0.0000	0.0027	NA	0.0000	0.0004
2017	0.0000	0.0509	0.0001	NA	0.0001	0.1270	0.1018	0.0000	0.0027	NA	0.0000	0.0004

The table above represents the fugitive emissions for CH_4 as being significantly higher compared to N_2O and CO_2. NMVOC emissions are calculated and reported for the purpose of completeness, but not commented in this document. Emissions from exploration are included elsewhere (I.E.).

3.3.2.1.2 Methodological issues

3.3.2.1.2.1 Choice of methods

For estimating the GHG emissions based on oil and natural gas production, the 2006 IPCC Guidelines Tier 1 method has been applied *(2006 IPCC GL, Vol. 2, Chap. 4)*:

Equation 4.2.1: Estimating fugitive emissions from an industry segment

$$E_{gas,industry\ segment} = A_{industry\ segment} \times EF_{gas,industry\ segment}$$

Where:

$E_{gas,\ industry\ segment}$ = annual emissions (Gg)

$EF_{gas,\ industry\ segment}$ = emission factor (Gg/unit of activity)

$A_{industry\ segment}$ = activity value (units of activity)

3.3.2.1.2.2 Choice of activity data

Data on oil and natural gas was sourced from the National Energy Balance of Afghanistan. There is no data for distribution of oil products, storage and distribution of natural gas.

Kandahar, Afghanistan © Fazlullah Fazli

Table 162 Activity data for Oil and natural gas systems (IPCC sub-category 1.B.2)

	1. B. 2. a. Oil			1. B. 2. b. Natural Gas					1. B. 2. c. Venting and Flaring			
									1. B. 2. c. 1 Venting		1. B. 2. c. 2 Flaring	
	i. Exploration	ii. Production	iv. Refining / Storage	ii. Production / Processing	iv. Transmission		v. Distribution		i. Oil	ii. Gas	i. Oil	ii. Gas
Year	*10^3m^3*	*10^3m^3*	*10^3m^3*	*10^6m^3*	*10^6m^3*	*km*	*10^6m^3*	*km*	*10^3m^3*	*10^6m^3*	*10^3m^3*	*10^6m^3*
1988	0.0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1990	0.6	0.6	0.6	215.6	215.6	89	0.0	0	0.1	215.6	0.1	215.6
1995	0.9	0.9	0.9	172.9	172.9	89	0.0	0	0.1	172.9	0.1	172.9
2000	1.0	1.0	1.0	120.1	120.1	89	0.0	0	0.1	120.1	0.1	120.1
2005	1.0	1.0	1.0	177.1	177.1	89	0.0	0	0.1	177.1	0.1	177.1
2010	2.0	2.0	2.0	141.9	141.9	89	0.0	0	0.2	141.9	0.2	141.9
2011	2.2	2.2	2.2	161.4	161.4	89	0.0	0	0.2	161.4	0.2	161.4
2012	2.4	2.4	2.4	160.3	160.3	89	0.0	0	0.2	160.3	0.2	160.3
2013	3.4	3.4	3.4	154.5	154.5	89	0.0	0	0.3	154.5	0.3	154.5
2014	3.2	3.2	3.2	141.9	141.9	89	0.0	0	0.3	141.9	0.3	141.9
2015	2.9	2.9	2.9	146.2	146.2	89	0.0	0	0.3	146.2	0.3	146.2
2016	2.6	2.6	2.6	165.3	165.3	89	0.0	0	0.3	165.3	0.3	165.3
2017	2.6	2.6	2.6	160.8	160.8	89	0.0	0	0.3	0.0	0.3	160.8

3.3.2.1.2.3 Choice of emission factors

As country specific information was insufficient to derive CS factors, the following default emissions factors were applied.

Table 163 Default emissions factors for fugitive emissions from oil and natural gas (IPCC sub-category 1.B.2)

IPCC Category	GHG	Process	Default EF	Unit	Source
1. B. 2. a. Oil	CH_4	i. Exploration	0	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.5. Well drilling, testing and servicing
	CO_2	i. Exploration	0	$Gg/10^3m^3$	EF = sum of all 3 categories for "Wells"; Table 4.2.5 2006 IPCC Chapter 4
	N_2O	i. Exploration	0	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.5. Well testing
	CH_4	ii. Production	0.0196	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Oil production - Default Weighted Total
	CO_2	ii. Production	0.00249	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Oil production - Default Weighted Total
	N_2O	ii. Production	NA	$Gg/10^3m^3$	2006 IPCC; table 4.2.4 Default Weighted Total - Flaring
	CH_4	iii. Transport	0.000025	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Oil transport - Tanker Trucks and Rail Cars
	CO_2	iii. Transport	0.0000023	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Oil transport - Tanker Trucks and Rail Cars
	N_2O	iii. Transport	NA		
	CH_4	iv. Refining / Storage	NA	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Average for Oil Refining
1. B. 2. b. Natural Gas	CH_4	ii. Production	0.00000088	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas production
	CO_2	ii. Production	0.0014	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas production
	N_2O	ii. Production	0.000000025	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas production
	CH_4	iii. Processing	0.00079	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas processing - Default Weighted Total
	CO_2	iii. Processing	0.00025	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas processing - Default Weighted Total
	N_2O	iii. Processing	NA	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas processing - Default Weighted Total

IPCC Category	GHG	Process	Default EF	Unit	Source
	CH_4	iv. Transmission	0.00063335	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas transmission
	CO_2	iv. Transmission	0.00000144	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas transmission
	N_2O	iv. Transmission	NA	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas transmission
	CH_4	iv. Storage	0.0000415	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas storage
	CO_2	iv. Storage	0.000000185	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas storage
	N_2O	iv. Storage	NA		IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas storage
	CH_4	v. Distribution	0.0018	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas distribution
	CO_2	v. Distribution	0.0000955	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas distribution
	N_2O	v. Distribution	NA	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Chap. 4, Fugitive, Table 4.2.4. Gas distribution

Table 164 Default emissions factors from Venting and Flaring (IPCC sub-category 1.B.2)

IPCC Category	GHG	Default EF	Unit	Note
	1. B. 2. c. Venting and Flaring			
	1. B. 2. c. 1 Venting			
Oil	CH_4	0.01035	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Ch. 4, Fugitive, Table 4.2.4. Oil production - Default Weighted Total
	CO_2	0.00215	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Ch. 4, Fugitive, Table 4.2.4. Oil production - Default Weighted Total
	N_2O	NA	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Ch. 4, Fugitive, Table 4.2.4. Oil production - Default Weighted Total
Natural gas	CH_4	NA	$Gg/10^6m^3$	2006 IPCC, Volume 2, chapter 4.2.2.3, Table 4.2.4 (Gas Transmission & Storage) Venting
	CO_2	0.0675	$Gg/10^6m^3$	2006 IPCC, Volume 2, chapter 4.2.2.3, Table 4.2.4 (Gas Processing) Raw CO_2 Venting
	N_2O	NA	NA	NA
	1. B. 2. c. 1 Flaring			
Oil	CH_4	0.000025	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Ch. 4, Fugitive, Table 4.2.4. Oil production - Default Weighted Total
	CO_2	0.0405	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Ch. 4, Fugitive, Table 4.2.4. Oil production - Default Weighted Total
	N_2O	0.00000064	$Gg/10^3m^3$	IPPC 2006, Vol. 2 Ch. 4, Fugitive, Table 4.2.4. Oil production - Default Weighted Total
Natural gas	CH_4	0.0000024	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Ch. 4, Fugitive, Table 4.2.4. Oil production - Default Weighted Total
	CO_2	0.00355	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Ch. 4, Fugitive, Table 4.2.4. Oil production - Default Weighted Total
	N_2O	3.94E-08	$Gg/10^6m^3$	IPPC 2006, Vol. 2 Ch. 4, Fugitive, Table 4.2.4. Oil production - Default Weighted Total

3.3.2.1.3 Uncertainties and time-series consistency

Among the major sources of uncertainty for estimating the fugitive emissions from the oil and natural gas industry are the following:

- Measurement errors
- Extrapolation errors
- Inherent uncertainties of the selected estimation techniques
- Missing or incomplete information regarding the source population and activity data
- Poor understanding of temporal and seasonal variations in the sources
- Over or under accounting due to confusion or inconsistencies in category divisions and source definitions
- Misapplication of activity data or emission factors
- Errors in reported activity data
- Differences in the effectiveness of control devices, etc.

As the uncertainty due to these sources is difficult to quantify and yet could be significant, for IPCC sub-category 1.B.2. *Oil and natural gas systems* the recommended uncertainties by 2006 IPCC GL were applied:

Table 165 Uncertainty for IPCC sub-category 1.B.1. Oil and natural gas systems

Uncertainty	Oil and natural gas systems	Reference
Combined Uncertainty (U)	150%	2006 IPCC GL, Vol. 2, Chap.4, Table 4.2.5. TIER 1 emission factors for fugitive emissions (including venting and flaring) from oil and gas operations in developing countries and countries with economies in transition

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.3.2.1.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ time series consistency - plausibility checks of dips and jumps.

3.3.2.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

3.3.3 Oil and Natural Gas (IPCC category 1.B.2)

This category will be considered in the next NIR.

3.4 Carbon dioxide Transport and Storage (IPCC category 1.C)

This section describes GHG emissions resulting from carbon dioxide transport, injection and geological storage (CCGS) only. All these activities are not existing in Afghanistan.

IPCC code	Description	Occurrent		Not occurrent (NO)
		Estimated	Not estimated (NE)	
1.C.1	**Transport of CO_2**			✓
1.C.1.a	Pipelines			✓
1.C.1.b	Ships			✓
1.C.1.b	Other (please specify)			✓
1.C.2	**Injection and Storage**			✓
1.C.2.a	Injection			✓
1.C.2.b	Storage			✓
1.C.3	**Other**			✓

4 Industrial Processes and Product Use (IPPU) (IPCC sector 2)

In the Sector *Industrial Processes and Product Use (IPPU),* emissions originating from industrial processes, from the use of greenhouse gases in products, and from non-energy uses of fossil fuel carbon are considered. Emissions from this sector comprise emissions from the following sub-categories:

- 2.A Mineral Industry,
- 2.B Chemical Industry,
- 2.C. Metal Industry,
- 2.D. Non-energy products from fuels and solvent use,
- 2.E Electronic Industry, Product uses as substitutes for ODS, and
- 2.F Other product manufacture and use.

Greenhouse gas emissions are produced from a wide variety of industrial activities. The main emission sources are releases from industrial processes that chemically or physically transform materials like

- ammonia production and finally urea production in category 2.B Chemical industry;
- cement and lime industry in category 2.A Mineral Industry.

Other Industries of the IPCC sector Industrial Processes and Product Use (IPPU), such as primary iron and steel industry, aluminum industry, electronic industries (e.g. semiconductor), or production of Electrical Equipment are not existing in Afghanistan.

During these processes, many different greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), can be produced.

The so-called F-gases hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), sulfur hexafluoride (SF6) and Other halogenated gases are oftentimes used in products such as refrigerators, foams or aerosol cans as well as electrical equipment.

Due to lack of data and resources GHG emissions from the use of greenhouse gases (HFC, PFC, SF_6) and Other halogenated gases used in products were not estimated in this inventory cycle. The estimation of these greenhouse gases are planned for the next inventory cycle (see Chapter 4.6).

Categories where emissions are not occurring (NO) because there is no such production in Afghanistan, and categories that are not estimated (NE) or included elsewhere (IE) are summarized in the following table, which gives an overview of the IPCC categories included in this sector and provides information on the status of emission estimates of all categories. A „✓" indicates that emissions from this sub-category have been estimated. None sub-category is key category.

Table 166 Overview of categories of IPCC sector *Industrial Processes and Product Use (IPPU) and* status of estimation.

IPCC Code	IPCC category	CO_2	CH_4	N_2O	HFC	PFC	SF6	NF3
2.A	**Mineral Industry**	✓	NA	NA	NA	NA	NA	NA
2.B	**Chemical Industry**	✓	NE/NO	NE/NO	NA	NA	NA	NA
2.C	**Metal Industry**	NO	NO	NO	NO	NO	NO	NA
2.D	**Other Production**	✓	NA	NA	NA	NA	NA	NA
2.E	**Production of HFC/PFC and SF6**	NA	NA	NA	NO	NO	NO	NO
2.F	**Consumption of HFC/PFC and SF6**	NA	NA	NA	NE	NE	NE	NE
2.G	**Other Product Manufacture and Use**	NO	NO	NE	NA	NA	NA	NA
2.H	**Other**	NA	NO	NA	NA	NA	NA	NA

Only **process related emissions** are considered in IPCC sector *Industrial Processes and Product Use (IPPU)*; emissions due to fuel combustion in manufacturing industries are allocated to IPCC category 1.A.*2 Fuel Combustion – Manufacturing Industries and Construction* (see Chapter 3).

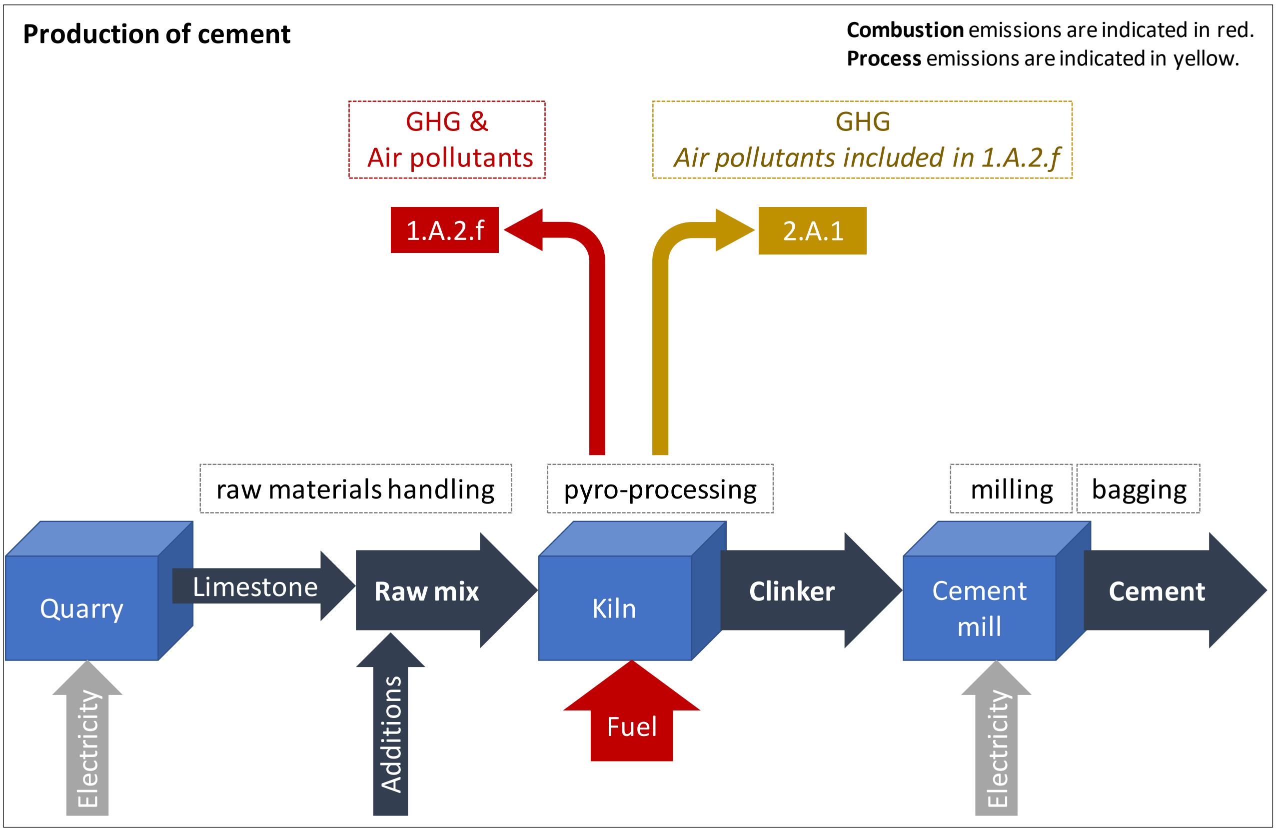


Figure 101 Illustration of combustion and process related emission (cement industry)

Emissions from the IPCC Sector *Industrial Processes and Product Use (IPPU)* are a small source of GHGs in Afghanistan:

- in 1990 about 1.4% of the total national GHG emissions and 4.8% of total CO_2 emissions arose from the sector IPPU, whereas N_2O and CH_4 emissions were not occurring.
- in 2005 about 0.7% of the total national GHG emissions and 3.4% of total CO_2 emissions arose from the sector IPPU, whereas N_2O and CH_4 emissions were not occurring.
- in 2017 about 5.6% of the total national GHG emissions and 1.2% of total CO_2 emissions arose from the sector IPPU, whereas N_2O and CH_4 emissions were not occurring.

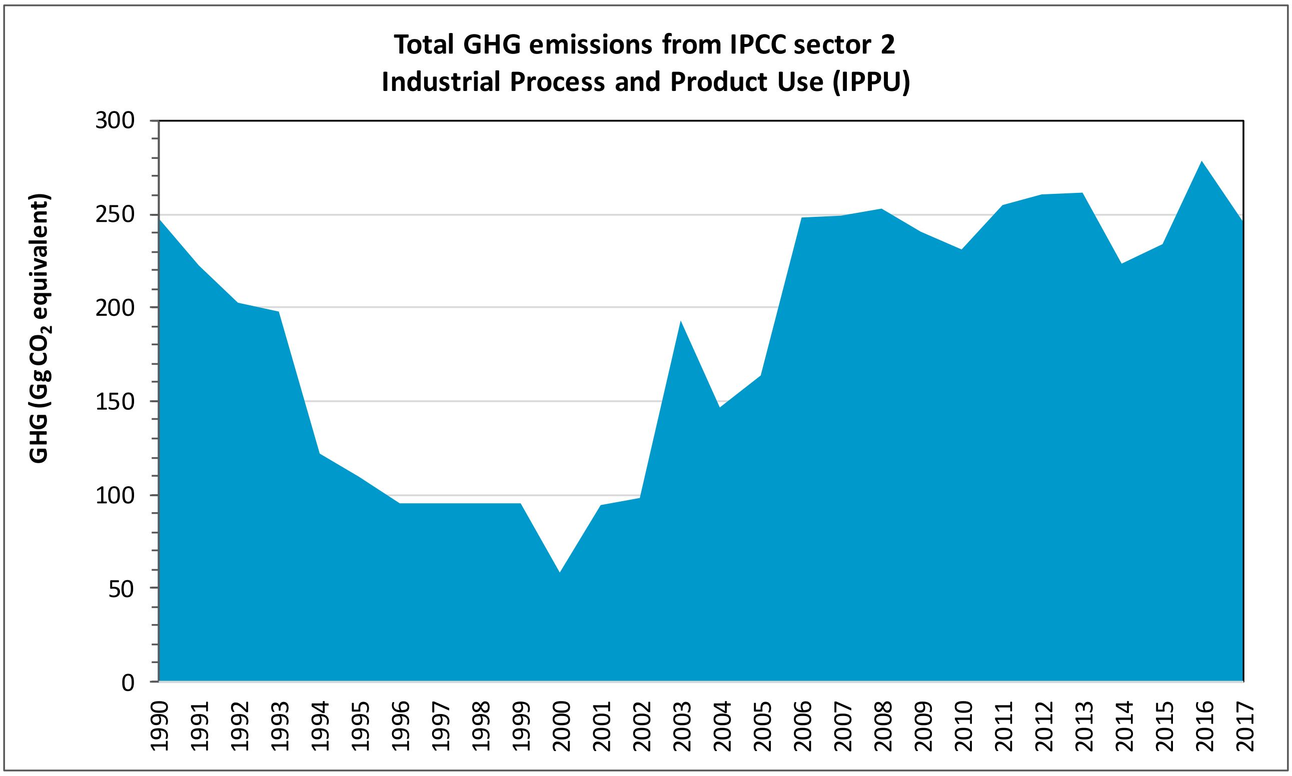


Figure 102 Trend of GHG emissions from 1990 – 2017 for IPCC sector Industrial Processes and Product Use (IPPU)

Emission trends

In the period, 1990 to 2017 GHG emissions from the IPCC Sector *Industrial Processes and Product Use (IPPU)* decreased slightly by 0.9% from 248.13 Gg CO_2 eq in 1990 to 245.78 Gg CO_2 eq in 2017. Emissions from the IPCC Sector *Industrial Processes and Product Use (IPPU)* decreased by 34% from 248.13 Gg CO_2 equivalents in 1990 to 163.84 Gg CO_2 equivalents in 2005. In the period, 2005 to 2017 GHG emissions from the IPCC Sector *Industrial Processes and Product Use (IPPU)* increased by 50% from 163.84 Gg CO_2 equivalents in 2005 to 245.78 Gg CO_2 equivalents in 2017. The decrease of emissions is mainly caused by production reduction during the Afghan war. The increase of GHG emission are due to the increased production in the chemical industry also due to a significant increase of cement production in the Mineral industry. The use of lubricants in category 2.D *Non-Energy Products from Fuels and Solvent Use* was over the whole period stable. The significant jumps and dips in the last decade are due to fuel shortage, shut down and/or maintenances of the plants.

In the period 2016 to 2017 GHG emissions from the IPCC Sector *Industrial Processes and Product Use (IPPU)* decreased by 1.4% from 278.59 Gg CO_2 eq in 2016 to 245.78 Gg CO_2 eq in 2017, which is mainly caused by decreasing emissions from Mineral industry – here mainly cement production (IPCC subcategory 2.A.1).

Only CO_2 emission arose from IPCC Sector *Industrial Processes and Product Use (IPPU)* since only few industries of the Mineral and Chemical industries occur in Afghanistan and the so-called F-gases are not estimated.

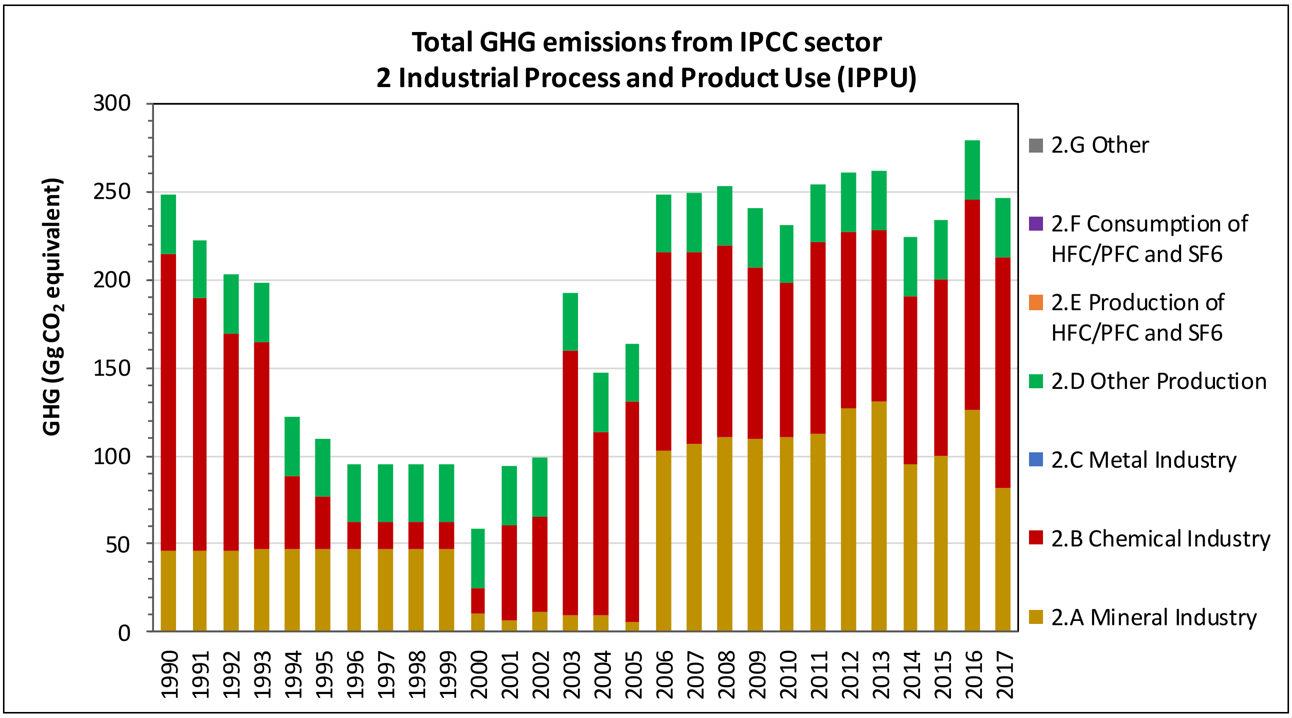


Figure 103 Total national GHG emissions by category of IPCC sector Industrial Processes and Product Use (IPPU)

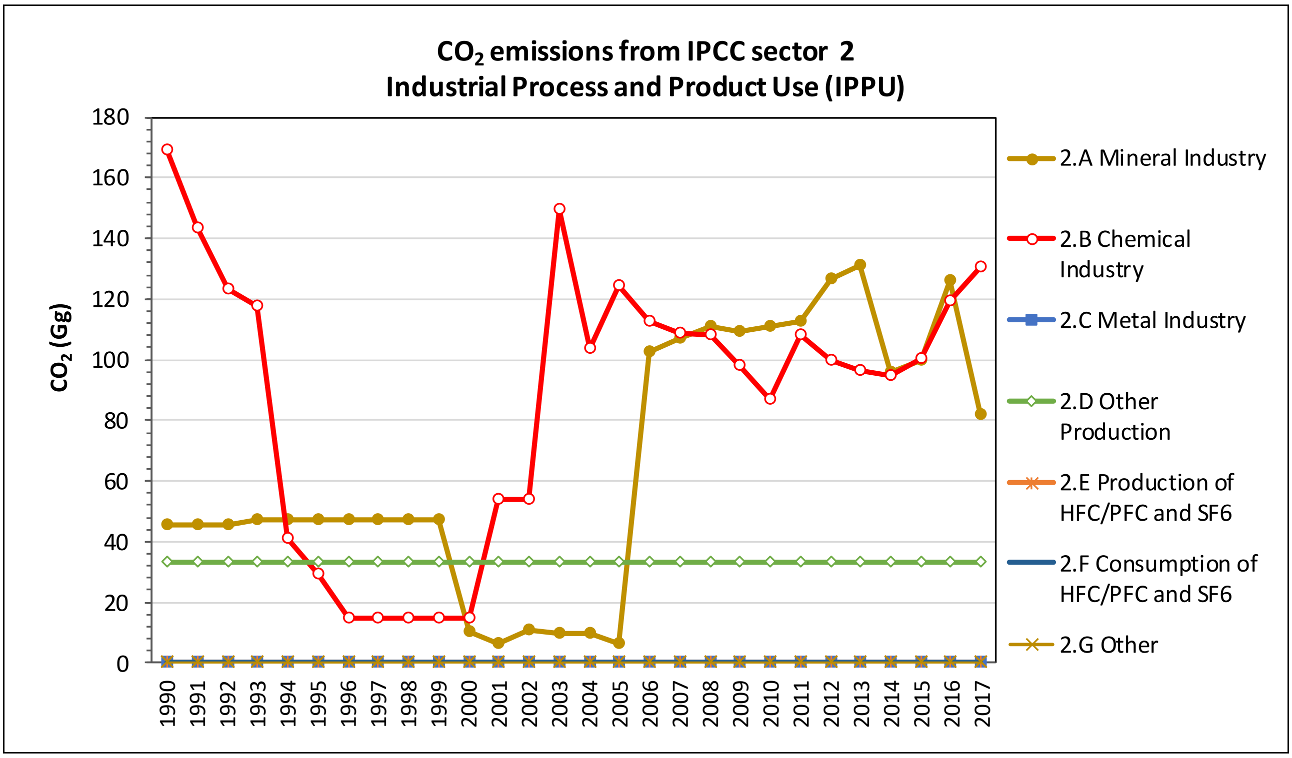


Figure 104 CO_2 emissions by category of IPCC sector Industrial Processes and Product Use (IPPU)

Table 167 Emissions from IPCC Sector Industrial Processes and Product Use (IPPU)

GHG emissions	TOTAL GHG	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NF_3
	Gg CO_2 equivalent	Gg	Gg CO_2 equivalent					
1990	248.13	248.13	NO	NE	NE	NE	NE	NE
1991	222.62	222.62	NO	NE	NE	NE	NE	NE
1992	202.68	202.68	NO	NE	NE	NE	NE	NE
1993	197.96	197.96	NO	NE	NE	NE	NE	NE
1994	121.73	121.73	NO	NE	NE	NE	NE	NE
1995	110.00	110.00	NO	NE	NE	NE	NE	NE
1996	95.54	95.54	NO	NE	NE	NE	NE	NE
1997	95.54	95.54	NO	NE	NE	NE	NE	NE
1998	95.54	95.54	NO	NE	NE	NE	NE	NE
1999	95.54	95.54	NO	NE	NE	NE	NE	NE
2000	58.48	58.48	NO	NE	NE	NE	NE	NE
2001	94.09	94.09	NO	NE	NE	NE	NE	NE
2002	98.58	98.58	NO	NE	NE	NE	NE	NE
2003	192.65	192.65	NO	NE	NE	NE	NE	NE
2004	146.70	146.70	NO	NE	NE	NE	NE	NE
2005	163.84	163.84	NO	NE	NE	NE	NE	NE
2006	248.43	248.43	NO	NE	NE	NE	NE	NE
2007	249.10	249.10	NO	NE	NE	NE	NE	NE
2008	252.65	252.65	NO	NE	NE	NE	NE	NE
2009	240.55	240.55	NO	NE	NE	NE	NE	NE
2010	231.32	231.32	NO	NE	NE	NE	NE	NE
2011	254.34	254.34	NO	NE	NE	NE	NE	NE
2012	260.30	260.30	NO	NE	NE	NE	NE	NE
2013	261.31	261.31	NO	NE	NE	NE	NE	NE
2014	223.77	223.77	NO	NE	NE	NE	NE	NE
2015	233.87	233.87	NO	NE	NE	NE	NE	NE
2016	278.59	278.59	NO	NE	NE	NE	NE	NE
2017	245.78	245.78	NO	NE	NE	NE	NE	NE
Trend								
1990 - 2017	*-0.9%*	*-0.9%*	-	-	-	-	-	-
2005 - 2017	*50.0%*	*50.0%*	-	-	-	-	-	-
2012 - 2017	*-5.6%*	*-5.6%*	-	-	-	-	-	-
2016 - 2017	*-11.8%*	*-11.8%*	-	-	-	-	-	-

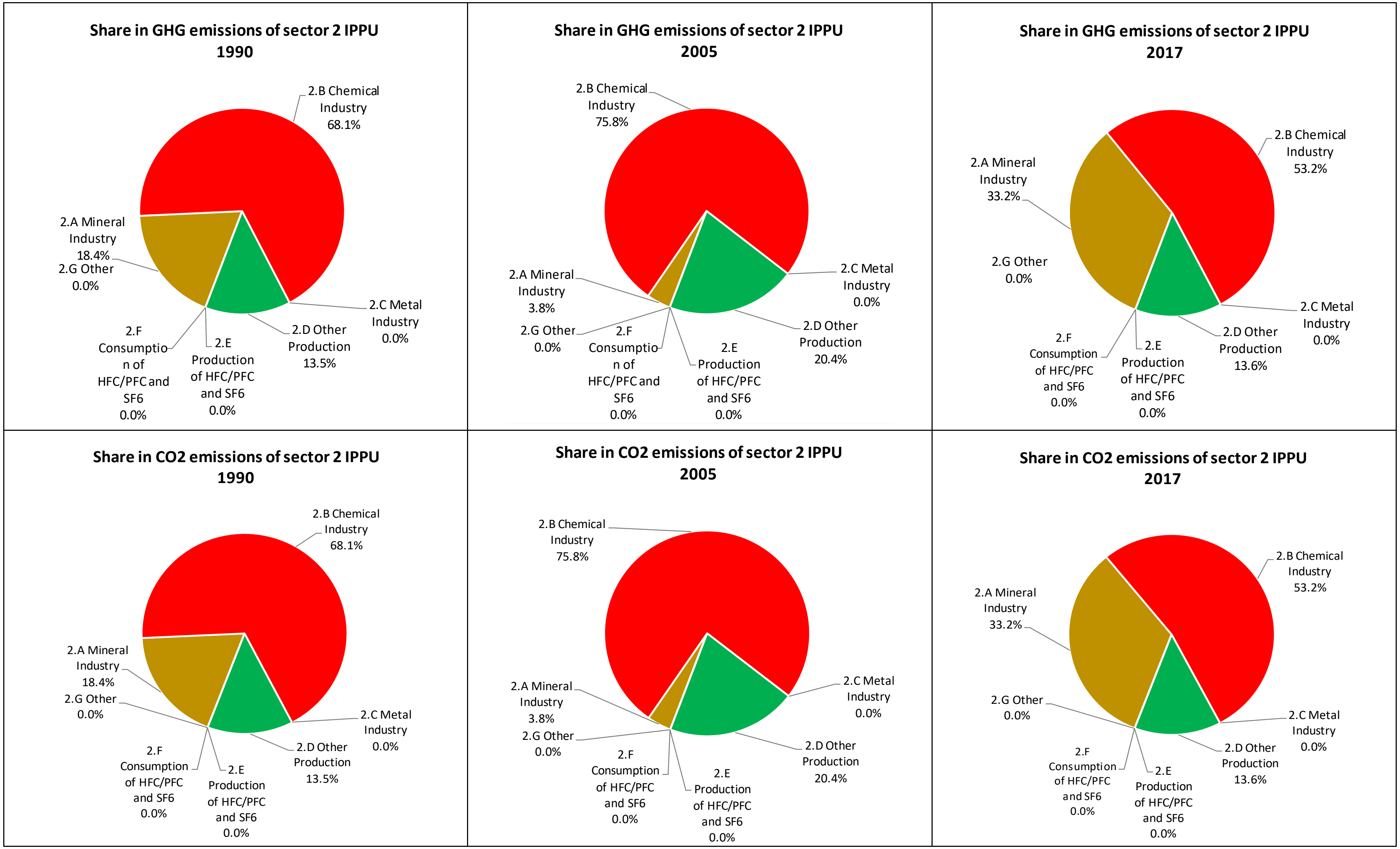


Figure 105 **Share of GHG and CO_2 emissions in IPCC Sector Industrial Processes and Product Use (IPPU) in 1990, 2005 and 2017**

Table 168 GHG Emissions from IPCC Sector Industrial Processes and Product Use (IPPU) by sub-categories

GHG emissions	2 Industrial Processes and Product Use (IPPU)	2.A Mineral Industry	2.B Chemical Industry	2.C Metal Industry	2.D Other Production	2.E Production of HFC/PFC and SF6	2.F Consumption of HFC/PFC and SF6	2.G Other
	Gg $_{CO_2 \text{ equivalent}}$							
1990	248.13	45.77	168.93	NO	33.43	NO	NE	NO
1991	222.62	45.77	143.42	NO	33.43	NO	NE	NO
1992	202.68	45.77	123.48	NO	33.43	NO	NE	NO
1993	197.96	46.99	117.53	NO	33.43	NO	NE	NO
1994	121.73	46.99	41.30	NO	33.43	NO	NE	NO
1995	110.00	46.99	29.57	NO	33.43	NO	NE	NO
1996	95.54	47.40	14.70	NO	33.43	NO	NE	NO
1997	95.54	47.40	14.70	NO	33.43	NO	NE	NO
1998	95.54	47.40	14.70	NO	33.43	NO	NE	NO
1999	95.54	47.40	14.70	NO	33.43	NO	NE	NO
2000	58.48	10.22	14.83	NO	33.43	NO	NE	NO
2001	94.09	6.54	54.12	NO	33.43	NO	NE	NO
2002	98.58	11.03	54.12	NO	33.43	NO	NE	NO
2003	192.65	9.81	149.41	NO	33.43	NO	NE	NO
2004	146.70	9.81	103.46	NO	33.43	NO	NE	NO
2005	163.84	6.21	124.19	NO	33.43	NO	NE	NO
2006	248.43	102.54	112.46	NO	33.43	NO	NE	NO
2007	249.10	106.99	108.68	NO	33.43	NO	NE	NO
2008	252.65	110.89	108.33	NO	33.43	NO	NE	NO

GHG emissions	2 Industrial Processes and Product Use (IPPU)	2.A Mineral Industry	2.B Chemical Industry	2.C Metal Industry	2.D Other Production	2.E Production of HFC/PFC and SF6	2.F Consumption of HFC/PFC and SF6	2.G Other
	Gg CO_2 equivalent							
2009	240.55	109.26	97.86	NO	33.43	NO	NE	NO
2010	231.32	110.93	86.96	NO	33.43	NO	NE	NO
2011	254.34	112.48	108.42	NO	33.43	NO	NE	NO
2012	260.30	126.82	100.04	NO	33.43	NO	NE	NO
2013	261.31	131.18	96.70	NO	33.43	NO	NE	NO
2014	223.77	95.66	94.67	NO	33.43	NO	NE	NO
2015	233.87	99.92	100.51	NO	33.43	NO	NE	NO
2016	278.59	125.82	119.33	NO	33.43	NO	NE	NO
2017	245.78	81.68	130.67	NO	33.43	NO	NE	NO
Trend								
1990 - 2017	*-0.9%*	*78.5%*	*-22.6%*	*NA*	*0%*	*NA*	*NA*	*NA*
2005 - 2017	*50.0%*	*1215.1%*	*5.2%*	*NA*	*0%*	*NA*	*NA*	*NA*
2012 - 2017	*-5.6%*	*-35.6%*	*30.6%*	*NA*	*0%*	*NA*	*NA*	*NA*
2016 - 2017	*-11.8%*	*-35.1%*	*9.5%*	*NA*	*0%*	*NA*	*NA*	*NA*

Table 169 CO_2 Emissions from IPCC Sector Industrial Processes and Product Use (IPPU) by sub-categories

CO_2 emissions	2 Industrial Processes and Product Use (IPPU)	2.A Mineral Industry	2.B Chemical Industry	2.C Metal Industry	2.D Other Production	2.E Production of HFC/PFC and SF6	2.F Consumption of HFC/PFC and SF6	2.G Other
	Gg							
1990	248.13	45.77	168.93	NO	33.43	NO	NE	NO
1991	222.62	45.77	143.42	NO	33.43	NO	NE	NO
1992	202.68	45.77	123.48	NO	33.43	NO	NE	NO
1993	197.96	46.99	117.53	NO	33.43	NO	NE	NO
1994	121.73	46.99	41.30	NO	33.43	NO	NE	NO
1995	110.00	46.99	29.57	NO	33.43	NO	NE	NO
1996	95.54	47.40	14.70	NO	33.43	NO	NE	NO
1997	95.54	47.40	14.70	NO	33.43	NO	NE	NO
1998	95.54	47.40	14.70	NO	33.43	NO	NE	NO
1999	95.54	47.40	14.70	NO	33.43	NO	NE	NO
2000	58.48	10.22	14.83	NO	33.43	NO	NE	NO
2001	94.09	6.54	54.12	NO	33.43	NO	NE	NO
2002	98.58	11.03	54.12	NO	33.43	NO	NE	NO
2003	192.65	9.81	149.41	NO	33.43	NO	NE	NO
2004	146.70	9.81	103.46	NO	33.43	NO	NE	NO
2005	163.84	6.21	124.19	NO	33.43	NO	NE	NO
2006	248.43	102.54	112.46	NO	33.43	NO	NE	NO
2007	249.10	106.99	108.68	NO	33.43	NO	NE	NO
2008	252.65	110.89	108.33	NO	33.43	NO	NE	NO

CO_2 emissions	2 Industrial Processes and Product Use (IPPU)	2.A Mineral Industry	2.B Chemical Industry	2.C Metal Industry	2.D Other Production	2.E Production of HFC/PFC and SF6	2.F Consumption of HFC/PFC and SF6	2.G Other
	Gg							
2009	240.55	109.26	97.86	NO	33.43	NO	NE	NO
2010	231.32	110.93	86.96	NO	33.43	NO	NE	NO
2011	254.34	112.48	108.42	NO	33.43	NO	NE	NO
2012	260.30	126.82	100.04	NO	33.43	NO	NE	NO
2013	261.31	131.18	96.70	NO	33.43	NO	NE	NO
2014	223.77	95.66	94.67	NO	33.43	NO	NE	NO
2015	233.87	99.92	100.51	NO	33.43	NO	NE	NO
2016	278.59	125.82	119.33	NO	33.43	NO	NE	NO
2017	245.78	81.68	130.67	NO	33.43	NO	NE	NO
Trend								
1990 - 2017	*-0.9%*	*78.5%*	*-22.6%*	*NA*	*0%*	*NA*	*NA*	*NA*
2005 - 2017	*50.0%*	*1215.1%*	*5.2%*	*NA*	*0%*	*NA*	*NA*	*NA*
2012 - 2017	*-5.6%*	*-35.6%*	*30.6%*	*NA*	*0%*	*NA*	*NA*	*NA*
2016 - 2017	*-11.8%*	*-35.1%*	*9.5%*	*NA*	*0%*	*NA*	*NA*	*NA*

4.1 Mineral Industry (IPCC category 2.A)

The IPCC category 2.A comprises the process-related carbon dioxide (CO_2) emissions resulting from the use of carbonate raw materials such as limestone and dolomite in the production and use of a variety of mineral industry products.

AS described in the 2006 IPCC Guidelines, Vol. 3, Chap 1, there are two broad pathways for release of CO_2 from carbonates:

(1) Calcination, and
(2) acid-induced release of CO_2.

Ad (1): The primary process resulting in the release of CO_2 is the calcination of carbonate compounds, during which, through heating, a metallic oxide is formed. A typical calcination reaction, here shown for the mineral calcite or calcium carbonate, would be:

$$CACO_3 + heat \rightarrow CaO + CO_2$$

Ad (2): Acid-induced release of CO_2 as a result of small quantities of carbonate being present as an impurity in an acidification process to upgrade a non-carbonate material. The formation of CO_2 can be via an equation such as:

$$CACO_3 + H_2SO_4 \rightarrow CaSO4 + H_2O + CO_2$$

In the following table, an overview of the IPCC sub-categories included in this chapter is given and is provided information on the status of emission estimates of all subcategories. A „✓" indicates that emissions from this sub-category have been estimated. None sub-category is key category.

Table 170 Overview of sub-categories of category 2.A. *Mineral Industry* and status of estimation.

IPCC Code	IPCC Category	CO_2		CH_4		N_2O	
2.A	**Mineral Industry**	**Estimated**	**Key Category**	**Estimated**	**Key Category**	**Estimated**	**Key Category**
2.A.1	Cement production	✓	-	NA	-	NA	-
2.A.2	Lime production	✓	-	NA	-	NA	-
2.A.3	Glass Production	NO	-	NA	-	NA	-
2.A.4	Other Process Uses of Carbonates	NO	-	NA	-	NA	-
2.A.4.a	Ceramics	NE	-	NA	-	NA	-
2.A.4.b	Other Uses of Soda Ash	NO	-	NA	-	NA	-
2.A.4.c	Non Metallurgical Magnesia Production	NO	-	NA	-	NA	-
2.A.4.d	Other (please specify)	NO	-	NA	-	NA	-
2.A.5	Other (please specify)	NO	-	NA	-	NA	-

4.1.1 Cement production (IPCC subcategory 2.A.1)

4.1.1.1 Source category description

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.A.1	Cement production	✓	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

This chapter includes the CO_2 emissions estimations from cement production. Process-related CO_2 emissions are released during clinker production. Cement Production is a key source with regards to CO_2 emissions.

As described in the EMEP/EEA air pollutant emission inventory guidebook 2016[97]

> in cement manufacture, CO_2 is produced during the production of clinker, a nodular intermediate product that is then finely ground, along with a small proportion of calcium sulfate [gypsum ($CaSO_4 \cdot 2H_2O$) or anhydrite ($CaSO_4$)], into hydraulic (typically portland) cement. During the production of clinker, limestone, which is mainly calcium carbonate ($CaCO_3$), is heated, or calcined, to produce lime (CaO) and CO_2 as a by-product. The CaO then reacts with silica (SiO_2), alumina (Al_2O_3), and iron oxide (Fe_2O_3) in the raw materials to make the clinker minerals (chiefly calcium silicates). The proportion in the raw materials of carbonates other than $CaCO_3$ is generally very small. The other carbonates, if present, exist mainly as impurities in the primary limestone raw material. A small amount of MgO (typically 1-2 percent) in the clinker-making process is desirable as it acts as a flux, but much more than this amount can lead to problems with the cement (van Oss and Padovani, 2002).
>
> The production of clinker takes place in a kiln system in which the minerals of the raw mix are transformed at high temperatures into new minerals with hydraulic properties. The fine particles of the raw mix move from the cool end to the hot end of the kiln system and the combustion gases move the other way from the hot end to the cold end. This results in an efficient transfer of heat and energy to the raw mix and an efficient removal of pollutants and ash from the combustion process. During the passage of the kiln system the raw mix is dried, pre-heated, calcined and sintered to clinker, which is rapidly cooled with air and stored.
>
> The basic chemistry of the cement manufacturing process begins with decomposition of calcium carbonate at about 900 ˚C to leave calcium oxide (CaO) and liberated gaseous carbon dioxide (CO_2); this process is known as calcination. This is followed by the clinkering process in which the calcium oxide reacts at a high temperature (typically 1 400–1 500 ˚C) with silica, alumina, and ferrous oxide to form the silicates, aluminates and ferrites of calcium that constitute the clinker. The clinker is then rapidly cooled.

In Afghanistan Cement is made entirely from national produced clinker; no clinker is imported for cement production.

The cement industry is highly energy intensive. According to EMEP EEA Guidebook 2016[97] the theoretical thermal energy demand for the chemical/mineralogical reactions of clinker production (not including drying and preheating) is about 1 700 MJ/tonne clinker. The actual thermal energy demand for different kiln systems and sizes is approximately 3 000 – 6 500 MJ/tonne clinker (European Commission, 2010). According to the IPCC guidelines, the energy-related emissions from fuel consumption are accounted for in the IPCC Sector 1.A.2.f. (marked in red and yellow in the figure below).

[97] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, 2.A.1 Cement production, sub-chapter 2.1.2 Pyro-processing to produce clinker. Available (05. January 2019) on https://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/2-industrial-processes/2-a-mineral-products/2-a-1-cement-production-2016/view

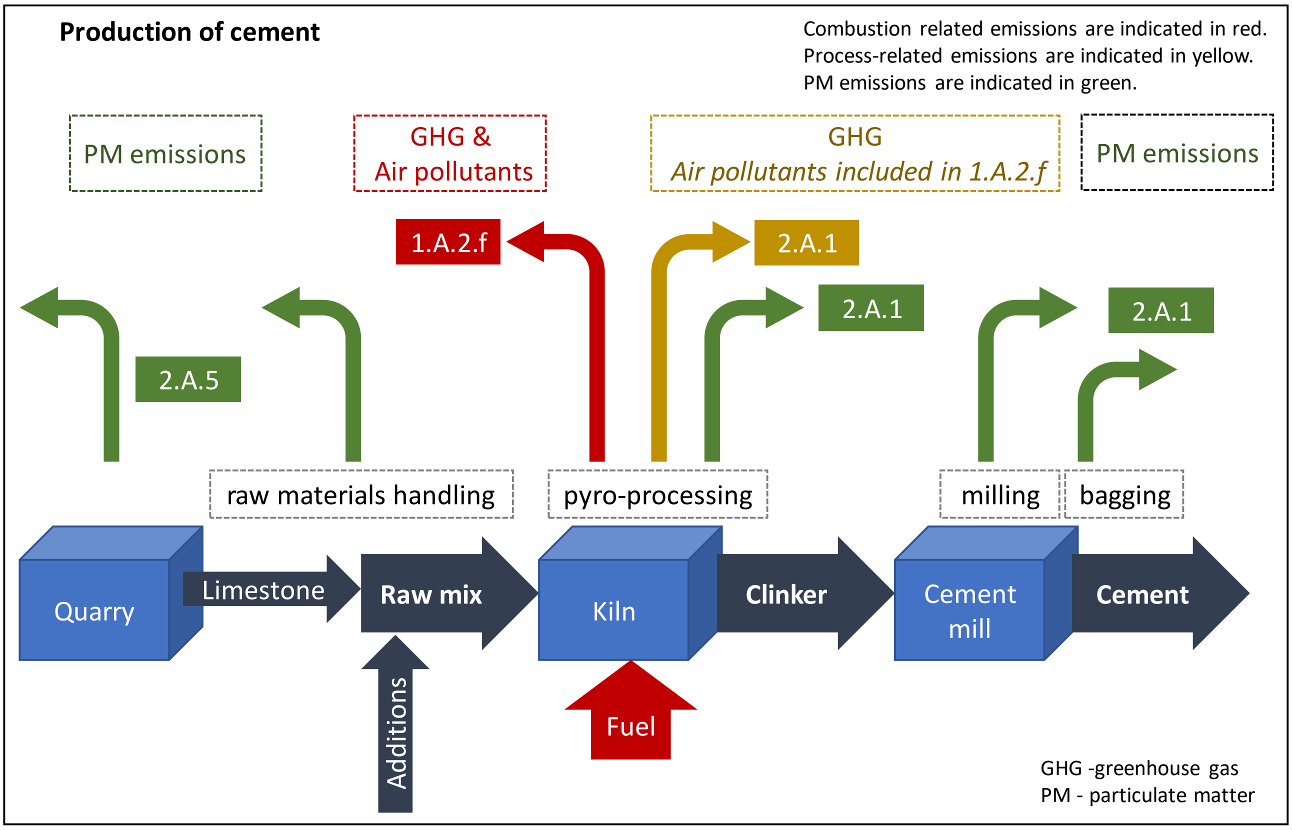


Figure 106 **Schematic illustration of cement production and allocation of emissions**

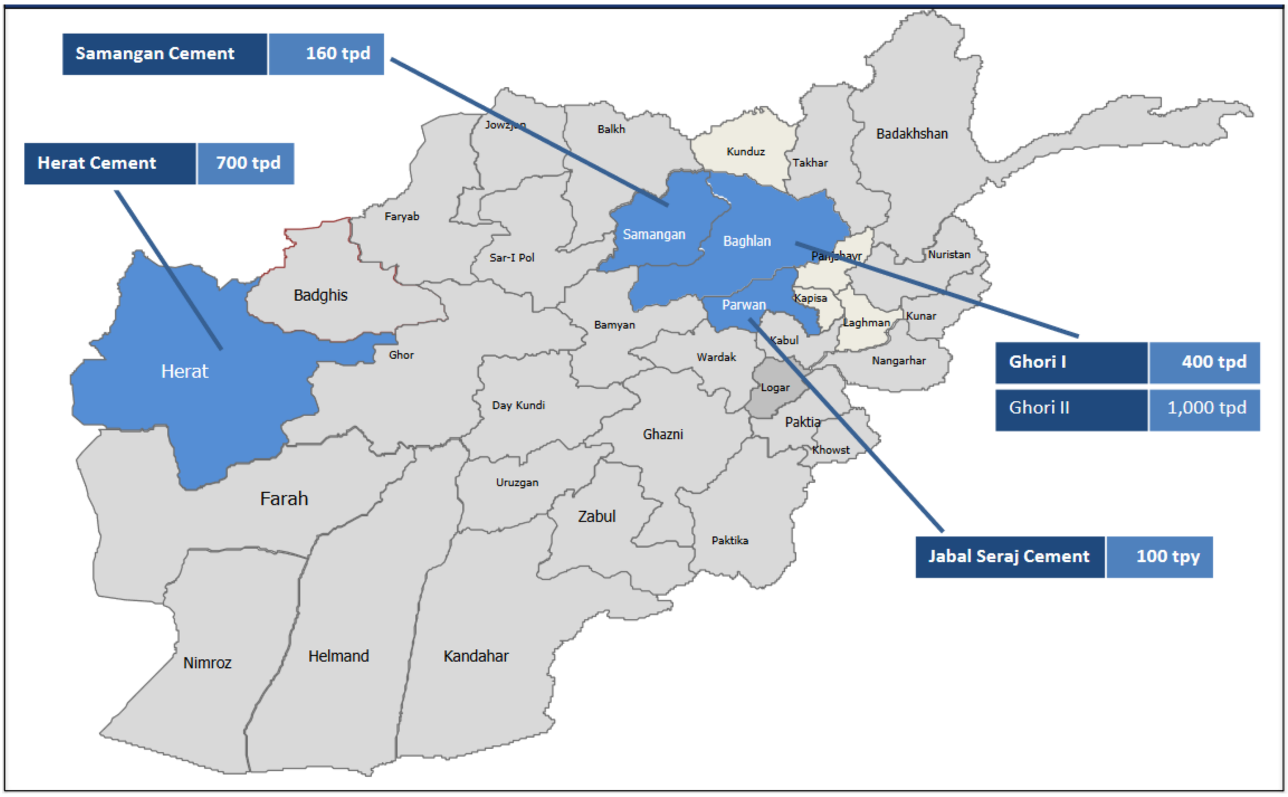


Figure 107 **Cement Industry of Afghanistan**

Source: Afghanistan Cement Industry, 2017[98]

[98] Available on 17.12.2018 at http://afghaneconomics.com/invest/AfghanistanCI.pdf

Table 171 Major operating Cement companies

Major cement producers	Name	Location	Annual capacity (t)
Afghan Cement L.L.C. (subsidiary of Government-owned Afghan Investment Co.)	Ghori I plant	Pul-e Khumri, Baghlan Province	51 000
	Ghori II plant		365 000
	Ghori III plant		No information
Jabal-e Saraj (Tasadee)	Jabal-e Saraj Cement plant	Parwan Province1	37 000
Herat Cement (planned to be corporatized)	Herat Cement plant	Herat Province1	21 000
Samangan Cement (planned to be corporatized)	Samangan Cement plant	Aybak District of Samangan	No information

Source: USGS Minerals Yearbook: The Mineral Industry of Afghanistan, different years.

The current demand for cement in Afghanistan is met mainly (99%) by imports from the neighboring countries. As reconstructing of the infrastructure will lead to an increasing consumption of this basic building material, national supplies are expected to grow. Afghanistan currently has five cement plants with a total annual capacity of about 474 000 t in 2017 (Ministry of Mining and Petroleum, 2017). This positions the country among the smallest scale producers in the world. Cement production in Afghanistan is the lowest in the world in terms of kg/capita/year

Table 172 Annual Cement production in Afghanistan in terms of kg per capita

1990	1995	2000	2005	2010	2015
6.9	6.5	6.1	0.7	1.5	3.7

Cement production was responsible for about 18 of GHG emissions in CO_{2e} from industrial processes in 2017 and 1990 and for less than 1% of the total CO_2 emissions estimated in 2017 and 1990. It represented less than 0.3% of the total GHG emissions in 1990 and 217. Compared to 1990, emissions decreased by 2.1% to attain the level of 44.78 Gg CO_2 in 2017. Compared to 2005, emissions increased by 621%from 5.89Gg. In the period 2016 - 2017 the cement production and CO_2 emissions from cement industry decreased by 41%. The fluctuation are mainly due to

- fuel shortage;
- maintenance periods;
- cement plants are in poor condition due to age of the plants and lack of sufficient resources for both routine maintenance and for the type of capital projects which most plants require through their lives for betterment, upgrades and partial replacement of equipment;
- economic downturn due to the Afghan Civil War (1989–92, 1996–2001) and War in Afghanistan (2001–present).

An overview of the cement production (IPCC sub-category 2.A.1) related CO_2 emissions is provided in the following figure and table.

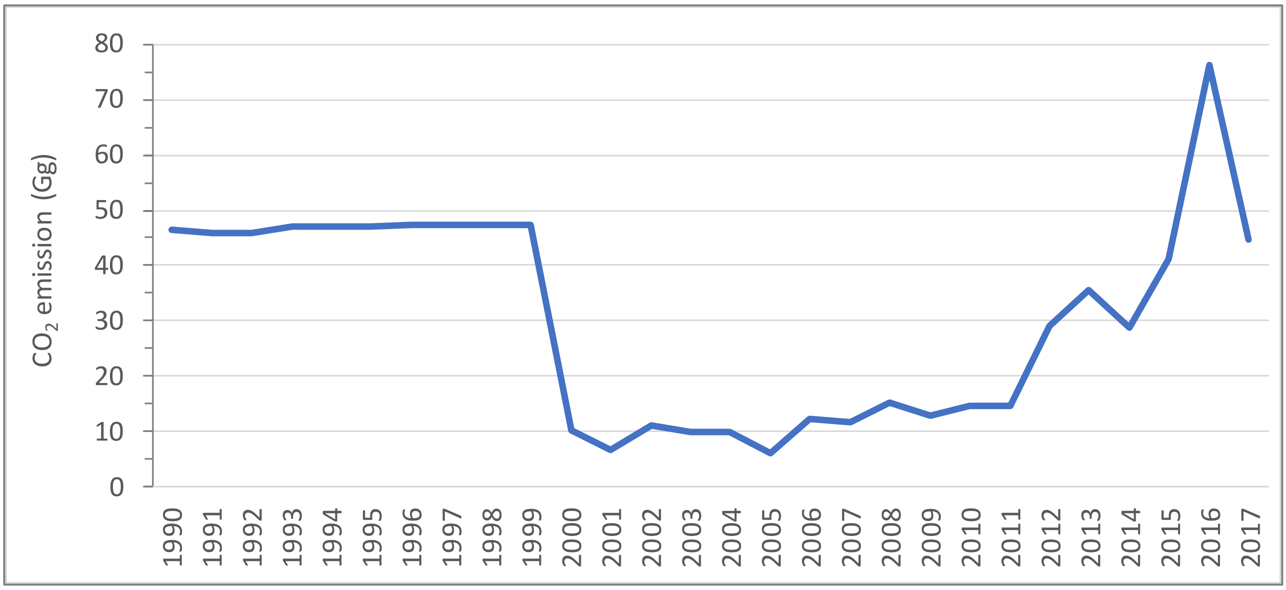


Figure 108 **CO_2 emissions from IPCC sub-category 2.A.1 Cement production 1990-2017**

Table 173 **Activity data, CO_2 emission factor and CO_2 emissions from Cement production (IPCC sub-category 2.A.1)**

Years	Clinker production	CO_2 emission factor for clinker		Emissions correction factor for cement kiln dust (CKD)	CO_2 emission
		excluding Emissions correction factor for cement kiln dust (CKD)	including Emissions correction factor for cement kiln dust (CKD)		
	tonnes	tonnes of CO_2/ tonnes of clinker		-	Gg
1990	107 520	0.4173	0.4256	1.02	45.766
1991	107 520	0.4173	0.4256	1.02	45.766
1992	107 520	0.4173	0.4256	1.02	45.766
1993	110 400	0.4173	0.4256	1.02	46.991
1994	110 400	0.4173	0.4256	1.02	46.991
1995	110 400	0.4173	0.4256	1.02	46.991
1996	111 360	0.4173	0.4256	1.02	47.400
1997	111 360	0.4173	0.4256	1.02	47.400
1998	111 360	0.4173	0.4256	1.02	47.400
1999	111 360	0.4173	0.4256	1.02	47.400
2000	24 000	0.4173	0.4256	1.02	10.216
2001	15 360	0.4173	0.4256	1.02	6.538
2002	25 920	0.4173	0.4256	1.02	11.033
2003	23 040	0.4173	0.4256	1.02	9.807
2004	23 040	0.4173	0.4256	1.02	9.807
2005	14 592	0.4173	0.4256	1.02	6.211
2006	28 608	0.4173	0.4256	1.02	12.177
2007	27 264	0.4173	0.4256	1.02	11.605
2008	35 808	0.4173	0.4256	1.02	15.242

Years	Clinker production	CO_2 emission factor for clinker		Emissions correction factor for cement kiln dust (CKD)	CO_2 emission
		excluding Emissions correction factor for cement kiln dust (CKD)	including Emissions correction factor for cement kiln dust (CKD)		
	tonnes	tonnes of CO_2/ tonnes of clinker		-	Gg
2009	30 240	0.4173	0.4256	1.02	12.872
2010	34 176	0.4173	0.4256	1.02	14.547
2011	34 272	0.4173	0.4256	1.02	14.588
2012	67 968	0.4173	0.4256	1.02	28.930
2013	83 520	0.4173	0.4256	1.02	35.550
2014	67 296	0.4173	0.4256	1.02	28.644
2015	96 768	0.4173	0.4256	1.02	41.189
2016	178 848	0.4173	0.4256	1.02	76.126
2017	105 216	0.4173	0.4256	1.02	44.785
Trend					
1990 – 2017	*-2%*	-	-		*-2%*
2005 - 2017	*621%*	-	-		*621%*
2016 - 2017	*-41%*	-	-		*-41%*

4.1.1.2 Methodological issues

4.1.1.2.1 Choice of methods

The 2006 IPCC Guidelines Tier 2 approach[99] has been applied:

Equation 2.2: Tier 2 - Emissions based on clinker production data
(2006 IPCC GL, Vol. 3, Chap. 2)

$$\boldsymbol{CO_2\ emissions = Mass_{cl} \times Emission\ \mathrm{Factor_{cl}} \times CF_{ckd}}$$

Where:

CO_2 Emissions = emissions of CO_2 from cement production. tonnes

$Mass_{cl}$ = weight (mass) of clinker produced. tonnes

EF_{cl} = emission factor for clinker. tonnes CO_2/tonne clinker

CF_{ckd} = emissions correction factor for Clinker Kiln Dust (CKD). dimensionless (see Equation 2.5)

with

$$\boldsymbol{Emission\ factor_{cl} = CaO_{content}\ x\ \left(\frac{molar\ mass_{CO2}}{molar\ mass_{CaO}}\right) + MgO_{content}\ x\ \left(\frac{molar\ mass_{CO2}}{molar\ mass_{MgO}}\right)}$$

[99] Source: 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 2: Mineral Industry Emissions, Sub-chapter 2.2 Cement Production

Based on national data a country specific emission factor was derived with

Equation 2.5: Correction factor for CKD not recycled to the kiln

$$CF_{ckd} = 1 + \left(\frac{M_d}{M_{cl}}\right) \times C_d \times F_d \times \left(\frac{EF_c}{EF_{cl}}\right)$$

Where:

CF_{ckd} = emissions correction factor for CKD. dimensionless

M_d = weight of CKD not recycled to the kiln. tonnes

M_{cl} = weight of clinker produced. tonnes

C_d = fraction of original carbonate in the CKD (i.e. before calcination). fraction

F_d = fraction calcination of the original carbonate in the CKD. fraction

EF_c = emission factor for the carbonate. tonnes CO_2/tonne carbonate

EF_{cl} = emission factor for clinker uncorrected for CKD. tonnes CO_2/tonne clinker

A default emissions correction factor for CKD from the IPCC GL was applied.

According to 2006 IPCC Guidelines the Tier 2 approach is based on the following assumptions about the cement industry and clinker production:

(1)	Only portland cement is produced.	✓
(2)	There is a very limited range in the CaO composition of clinker and the MgO content is kept very low.	see Table 176
(3)	Plants are generally able to control the CaO content of the raw material inputs and of the clinker within close tolerances	see Table 176
(4)	Even where the output of clinker is calculated by a plant rather than directly measured. There is generally close agreement between the two determination methods when audits are performed;	assumed
(5)	The CaO content of clinker from a given plant tends not to change significantly over the years;	✓
(6)	The main source of the CaO for most plants is $CaCO_3$ and at least at the plant level any major non-carbonate sources of CaO are readily quantified;	✓
(7)	A 100 percent (or very close to it) calcination factor is achieved for the carbonate inputs for clinker manufacture including (commonly to a lesser degree) material lost to the system as non-recycled CKD; and	assumed
(8)	Dust collectors at plants capture essentially all of the CKD although this material is not necessarily recycled to the kiln.	assumed

4.1.1.2.2 Choice of activity data

For Afghanistan, it was possible to collect country specific data on cement production and the chemical characteristics of limestone. The data used in the inventory are based on data for cement production provided for the years

- 2008 – 2017 by Ministry of Mining and Petroleum (MoMP) and National Statistics and Information Authority (NSIA)
- 1995 – 2007 UN Statistics Division (UNSD) - Industrial Commodity Statistics Database – Commodity: [37] Glass and glass products and other non-metallic products n.e.c. [100]
- 1990 – 1994 US Geological Survey (USGS) Minerals Yearbook (different years) [101].

According to national expert of Ministry of Mining and Petroleum (MoMP) in all cement plants only Portland cement is produced; thus the fraction of clinker of the total cement production is about 96% (see Table 174).

Table 174 Cement production, Clinker fraction and production as well as mineral fractions of limestone used

Years	Cement production	Source	Clinker fraction of cement	Clinker production	CaO content in clinker	MgO content in clinker	Emissions correction factor for CKD	IEF for clinker
	tonnes		%	tonnes	%	%		tCO_2/t clinker
1990	112 000	US Geological Survey (USGS)	96%	107 520	50.67	1.80	1.02	0.4256
1991	112 000		96%	107 520	50.67	1.80	1.02	0.4256
1992	112 000		96%	107 520	50.67	1.80	1.02	0.4256
1993	115 000		96%	110 400	50.67	1.80	1.02	0.4256
1994	115 000		96%	110 400	50.67	1.80	1.02	0.4256
1995	115 000	UN Statistics Division (UNSD)	96%	110 400	50.67	1.80	1.02	0.4256
1996	116 000		96%	111 360	50.67	1.80	1.02	0.4256
1997	116 000		96%	111 360	50.67	1.80	1.02	0.4256
1998	116 000		96%	111 360	50.67	1.80	1.02	0.4256
1999	116 000		96%	111 360	50.67	1.80	1.02	0.4256
2000	25 000		96%	24 000	50.67	1.80	1.02	0.4256
2001	16 000		96%	15 360	50.67	1.80	1.02	0.4256
2002	27 000		96%	25 920	50.67	1.80	1.02	0.4256
2003	24 000		96%	23 040	50.67	1.80	1.02	0.4256
2004	24 000		96%	23 040	50.67	1.80	1.02	0.4256
2005	15 200		96%	14 592	50.67	1.80	1.02	0.4256
2006	29 800	MoMP & NSIA	96%	28 608	50.67	1.80	1.02	0.4256
2007	28 400		96%	27 264	50.67	1.80	1.02	0.4256
2008	37 300		96%	35 808	50.67	1.80	1.02	0.4256
2009	31 500		96%	30 240	50.67	1.80	1.02	0.4256
2010	35 600		96%	34 176	50.67	1.80	1.02	0.4256
2011	35 700		96%	34 272	50.67	1.80	1.02	0.4256

[100] Available (16. January 2019) on http://data.un.org/Data.aspx?q=cement&d=ICS&f=cmID%3a37440-0

[101] Available (16. January 2019) on https://www.usgs.gov/centers/nmic/asia-and-pacific

Years	Cement production	Source	Clinker fraction of cement	Clinker production	CaO content in clinker	MgO content in clinker	Emissions correction factor for CKD	IEF for clinker
	tonnes		%	tonnes	%	%		tCO_2/t clinker
2012	70 800		96%	67 968	50.67	1.80	1.02	0.4256
2013	87 000		96%	83 520	50.67	1.80	1.02	0.4256
2014	70 100		96%	67 296	50.67	1.80	1.02	0.4256
2015	100 800		96%	96 768	50.67	1.80	1.02	0.4256
2016	186 300		96%	178 848	50.67	1.80	1.02	0.4256
2017	109 600		96%	105 216	50.67	1.80	1.02	0.4256
Trend								
1990-2017	*-2%*		-	*-2%*	-	-	-	-
2005-2017	*621%*		-	*621%*	-	-	-	-
2016-2017	*-41%*		-	*-41%*	-	-	-	-

4.1.1.2.3 Choice of emission factors

A country-specific (CS) CO_2 emission factor for clinker based on chemical characteristics of the limestone of the different regions was applied.

Parameter	Parameter description	Unit	Formula	2017
Mc	weight (mass) of cement produced of type i	tonne	-	**109 600**
CaO_cont	**CaO content (mass share) in clinker**	**%**		**0.5067**
M_CO_2	Molar mass - CaCO3 (+950°C) → CaO + CO_2 ↑	g/mole CO_2	stoichiometric equations	44.01
M_CaO	Molar mass - CaCO3 (+950°C) → CaO + CO_2 ↑	g/mole CaO	stoichiometric equations	56.08
M_CO_2/CaO	Molar mass - CaCO3 (+950°C) → CaO + CO_2 ↑		= M_CO_2 / M_CaO	0.78
MgO_cont	**MgO Content (mass share) in clinker**	**%**	**-**	**0.0180**
M_CO_2	Molar mass - MgCO3 (+950°C) → MgO + CO_2 ↑	g/mole CO_2	stoichiometric equations	44.01
M_MgO	Molar mass - MgCO3 (+950°C) → MgO + CO_2 ↑	g/mole MgO	stoichiometric equations	40.32
M_CO_2/MgO	Molar mass - MgCO3 (+950°C) → MgO + CO_2 ↑		= M_CO_2 / M_MgO	1.09
EFcl	**CO_2 emission factor for clinker**	tonnes of CO_2/ tonnes of clinker	=CaO_cont x (M_CO_2/CaO) + MgO_cont x (M_CO_2/MgO)	**0.4173**
CFckd	**Emissions correction factor for cement kiln dust**	-		1.02
CO_2	**CO_2 emissions**	**Gg CO_2**	**= Mc x EFcl x CFckd**	**44.78**

The **default** emissions correction factor for cement kiln dust (CF_{ckd}) of 1.02 was applied (2006 IPCC GL. Vol 3. Chap 2. sub-chap 2.2.1.2. (p. 2.12)).

In the following table the country specific (CS) CO_2 emission factor for clinker and as comparison the default EF for TIER 1 presented.

Table 175 Comparison of Country-specific and default CO_2 emission factor for clinker

CO_2 emission factor for clinker		
Tier 2		Tier 1
excluding Emissions correction factor for cement kiln dust (CKD)	including	default CKD included
tonnes of CO_2/ tonnes of clinker		
0.4173	0.4256	0.52

Table 176 Chemical Characteristics - concentration of relevant oxides - of the limestone used for Cement production

Location	CaO	$CaCO_3$	MgO	SO_3	SIO_2	AL_2O_3	Fe_2O_3	Source
	%							
Aybak District Samangan Province	51.80	93.787	0.7576	0.6226	0.8382	1.0550	0.8654	MoMP[102]
Jabul Saraj Parwan Province	53.18	94.000	1.2400	0.0800	1.2800	0.9400	-	MoMP[103]
Zandajan Herat Province	47.03	87.030	3.4050	-	2.9800	0.4110	0.7790	MoMP[104]
Average used in the inventory	52.49	93.894	0.9988	0.3513	1.0591	0.9975	0.8654	

Source: Ministry of Mines and Petroleum (MOM) (2014): Cement Quality Limestone at Aybak, Samangan Province, Afghanistan.
Ministry of Mines and Petroleum (MOM) (2014): Cement Quality Limestone in Jabul Saraj Parwan Province, Afghanistan
Ministry of Mines and Petroleum (MOM) (2014): Zandajan Herat Province, Afghanistan.

4.1.1.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 2.A.1 *Cement production* are presented in the following table.

Table 177 Uncertainty for IPCC sub-category 2.A.1 Cement production.

Uncertainty	CO_2	Reference
Activity data (AD)	10%	2006 IPCC GL, Vol. 3, Chap.1, Table 2.3 Default uncertainty values for cement production
Emission factor (EF)	35%	
Combined Uncertainty (U)	37%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

[102] Ministry of Mines and Petroleum (MOM) (2014): Cement Quality Limestone at Aybak, Samangan Province, Afghanistan. Available (16. January 2019) on http://mom.gov.af/Content/files/MoMP_CEMENT_Aybak_Samangan_Province_%20Midas_Jan_2014.pdf

[103] Ministry of Mines and Petroleum (MOM) (2014): Cement Quality Limestone in Jabul Saraj Parwan Province, Afghanistan. AGS Investor Data Package No. 4. Available (16. January 2019) on http://mom.gov.af/Content/files/Jabul_Seraj_Limestone.pdf

[104] Ministry of Mines and Petroleum (MOM) (2014): Zandajan Herat Province, Afghanistan. Available (16. January 2019) on http://mom.gov.af/Content/files/MoMP_CEMENT_Zandajan_Herat_Midas_Jan_2014.pdf

4.1.1.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed:

⇒ Checked of calculations by spreadsheets
- consistent use of production statistics from CSO,
- documented sources,
- use of units,
- record keeping; use of write protection,
- unique use of formulas; special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and international commodity statistics of UN;

⇒ cross checks with other relevant sectors (Energy) are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ emission factors check – IEF;

⇒ time series consistency
- plausibility checks of dips and jumps,
- yearly public trend repeated values.

⇒ verification
- TIER 1 calculation was performed; results of TIER 1 and Tier 2 were compared (see the following figure)

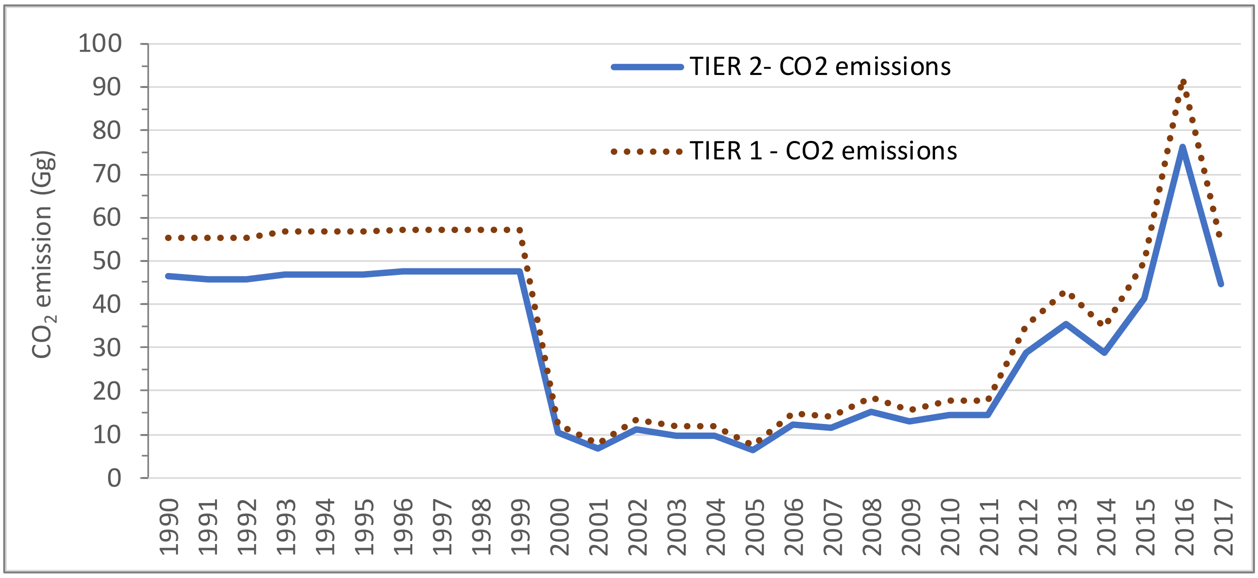


Figure 109 Comparison of CO_2 emissions from IPCC sub-category 2.A.1 Cement production based on Tier 1 and Tier 2 methodology 1990-2017

4.1.1.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 2.A.1 Cement production.

Table 178 Recalculations done since submission 2017 IPCC sub-category 2.A.1 Cement production

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
2.A.1	2006 IPCC Guidelines TIER 2 methodology was applied	method	Accuracy
2.A.1	CS emission factor was applied	EF	Accuracy Transparency

4.1.1.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.A.1	Investigation regarding clinker fraction of cement per plant	AD	Accuracy Transparency	High
2.A.1	Investigation regarding imports of Clinker	AD	Accuracy Transparency	Medium
2.A.1	Cross-check of national and international data sources	AD	Accuracy Transparency	Medium
2.A.1	Percentage share in cement kiln dust (CKD) which is recycled	AD	Accuracy, Transparency, Comparability	Medium

Brick Kiln in Daikundi, Afghanistan ©UNEP

4.1.2 Lime production (IPCC subcategory 2.A.2)

4.1.2.1 Source category description

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.A.2	Lime production	✓	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

This chapter includes the CO_2 emissions estimations from lime production. Process-related CO_2 emissions are released during (quick-)lime production. Calcium oxide (CaO), also called as quicklime, is formed by heating limestone to decompose the carbonates. This is usually done in shaft or rotary kilns at high temperatures and the process releases CO_2. Depending on the product requirements (e.g., metallurgy, pulp and paper, construction materials, effluent treatment, water softening, pH control, and soil stabilisation), primarily high calcium limestone (calcite) is utilized in accordance with the following reaction:

$$CaCO_3 \text{ (high-purity limestone)} + \text{heat} \rightarrow CaO \text{ (quicklime)} + CO_2$$

Lime production is not a key source.

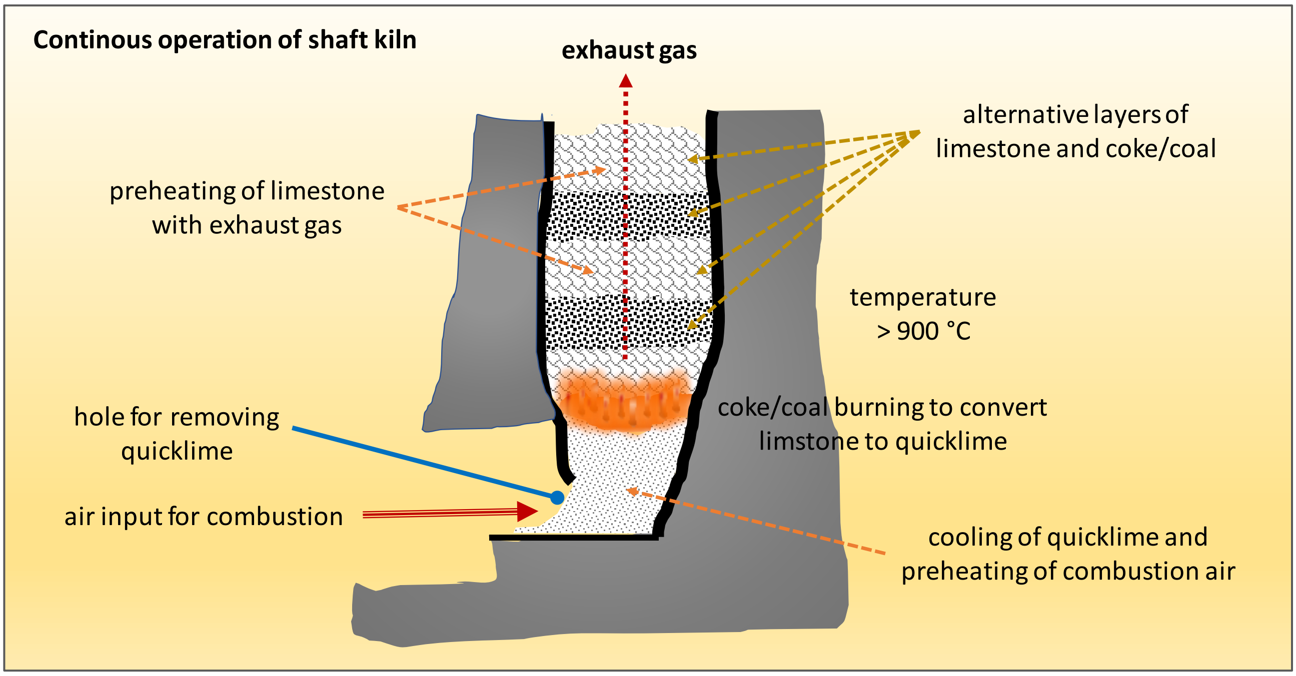


Figure 110 Illustration of a shaft kiln for lime production

In 2017-, lime production was responsible for less than 0.1% of GHG emissions in CO_{2eq} from industrial processes – the production started in 2006 – and for about 0.2% of the total CO_2 emissions estimated for Afghanistan. Compared to 2006, emissions decreased by -59.2% to attain the level of 36.90 Gg CO_2 in 2017. In the period 2016 - 2017 the lime production and CO_2 emissions from lime industry decreased by 25.8%. The decrease was mainly due to fuel shortage, maintenance periods and the War in Afghanistan.

An overview of the lime production (IPCC sub-category 2.A.2) related CO_2 emissions is provided in the following figure and table.

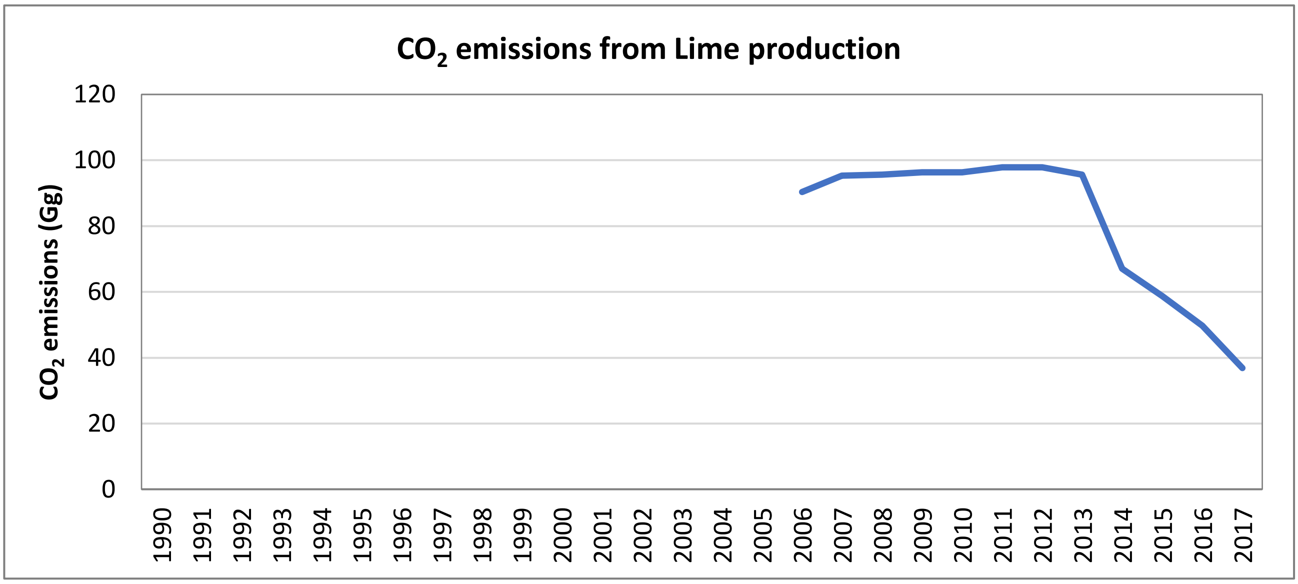


Figure 111 CO_2 emissions from IPCC sub-category 2.A.2 Lime production 1990-2017

Table 179 Activity data (AD), CO_2 emission factors (EF) and CO_2 emissions from Lime production (IPCC sub-category 2.A.2)

Year	Lime production	Share of lime type		CO_2 Emission factor (EF) for			CO_2 emissions
		high calcium lime	dolomitic lime	high calcium lime	dolomitic lime	lime	
	tonnes	%		(tonne CO_2 / t lime)			Gg
1990	NO	85	15	0.75	0.77	0.753	NO
⋮	⋮	-	-	-	-		⋮
2005	NO	85	15	0.75	0.77	0.753	NO
2006	120,000	85	15	0.75	0.77	0.753	90.36
2007	126,667	85	15	0.75	0.77	0.753	95.38
2008	127,017	85	15	0.75	0.77	0.753	95.64
2009	128,000	85	15	0.75	0.77	0.753	96.38
2010	128,000	85	15	0.75	0.77	0.753	96.38
2011	130,000	85	15	0.75	0.77	0.753	97.89
2012	130,000	85	15	0.75	0.77	0.753	97.89
2013	127,000	85	15	0.75	0.77	0.753	95.63
2014	89,000	85	15	0.75	0.77	0.753	67.02
2015	78,000	85	15	0.75	0.77	0.753	58.73
2016	66,000	85	15	0.75	0.77	0.753	49.70
2017	49,000	85	15	0.75	0.77	0.753	36.90
Trend							
1990 – 2017	*NA*	*0%*	*0%*	*0%*	*0%*	*0%*	*NA*
2005 - 2017	*NA*	*0%*	*0%*	*0%*	*0%*	*0%*	*NA*
2016 - 2017	*-25.8%*	*0%*	*0%*	*0%*	*0%*	*0%*	*-25.8%*

4.1.2.2 Methodological issues

4.1.2.2.1 Choice of methods

As is the case for emissions from cement production, there are three basic methodologies for estimating emissions from lime production: an output-based approach that uses default values (Tier 1), an output-based approach that estimates emissions from CaO and CaO·MgO production and country-specific information for correction factors (Tier 2) and an input-based carbonate approach (Tier 3).

The 2006 IPCC Guidelines Tier 1 approach[105] has been applied:

Equation: Tier 1 - Emissions based on national lime production data

(2006 IPCC Guidelines, Vol. 3, Chapter 2, sub-chapter 2.3.1.1)

$$CO_2\ emissions = Mass_{lime} \times Emission\ \mathrm{Factor}_{\mathrm{lime}}$$

based on

Equation 2.6: Tier 2 - Emissions based on national lime production data by type

$$CO_2\ emissions = \sum_i Mass_{lime,\mathrm{i}} \times Emission\ \mathrm{Factor}_{\mathrm{lime,i}} \times CF_{LKD,\mathrm{i}} \times C_{H,\mathrm{i}}$$

Where:

CO_2 Emissions	= emissions of CO_2 from lime production (tonnes)
$Mass_{lime}$	= weight (mass) of lime produced (tonnes)
EF_{lime}	= emission factor for lime (tonnes CO_2/tonne lime) (see Equation 2.9)
$CF_{Lkd,i}$	= emissions correction factor for Lime Kiln Dust (CKD) (dimensionless)
$C_{h,i}$	= correction factor for hydrated lime of the type i of lime (dimensionless)

According to 2006 IPCC Guidelines, Vol. 3, Chap. 2.3.1.1, the Tier 1 method is based on applying a default emission factor to national level lime production data. While country-specific information on lime production by type (e.g., high calcium lime, dolomitic lime, or hydraulic lime) is not necessary for *good practice* in Tier 1, where data are available to identify the specific types of lime produced in the country, this may be used. It is not necessary for *good practice* to account for LKD in Tier 1.

4.1.2.2.2 Choice of activity data

For Afghanistan it was possible to collect country specific data on lime production and the chemical characteristics of limestone. The data used in the inventory are based on data for lime production provided for the years

- 2006 – 2017 by Ministry of Mining and Petroleum (MoMP) and National Statistics and Information Authority (NSIA)
- 1990 – 2017 US Geological Survey (USGS) Minerals Yearbook (different years)[106].

In the absence of country specific data, it is *good practice* to assume 85% production of high calcium lime and 15% production of dolomitic lime.[107]

[105] Source: 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 2: Mineral Industry Emissions, Sub-chapter 2.3.1.1 Lime Production - Choice of method

[106] Available (16. January 2019) on https://www.usgs.gov/centers/nmic/asia-and-pacific

[107] 2006 IPCC Guidelines, Vol. 3, Chapter 2: Mineral Industry Emissions, Sub-chapter 2.3.1.2 Lime Production – Choice of emission factor, page 2.22.

Table 180 Activity data from Lime production (IPCC sub-category 2.A.2)

<table>
<tr><th rowspan="3">Year</th><th colspan="2" rowspan="2">Lime production</th><th colspan="4">Share of lime type</th></tr>
<tr><th colspan="2">high calcium lime</th><th colspan="2">dolomitic lime</th></tr>
<tr><th>tonnes</th><th>Source</th><th>%</th><th>Source</th><th>%</th><th>Source</th></tr>
<tr><td>1990</td><td>NO</td><td rowspan="3">US Geological Survey Mineral Yearbooks
NSIA, Statistical Yearbooks (YB)</td><td>-</td><td rowspan="3"></td><td>-</td><td rowspan="3"></td></tr>
<tr><td>⋮</td><td>⋮</td><td>-</td><td>-</td></tr>
<tr><td>2005</td><td>NO</td><td>-</td><td>-</td></tr>
<tr><td>2006</td><td>120,000</td><td rowspan="12">NSIA, Statistical Yearbooks (YB), Table 9-13</td><td>85</td><td rowspan="12">Chap. 2.3.1.2, Vol. 3, 2006 IPCC GL, page 2.22</td><td>15</td><td rowspan="12">Chap. 2.3.1.2, Vol. 3, 2006 IPCC GL, page 2.22</td></tr>
<tr><td>2007</td><td>126,667</td><td>85</td><td>15</td></tr>
<tr><td>2008</td><td>127,017</td><td>85</td><td>15</td></tr>
<tr><td>2009</td><td>128,000</td><td>85</td><td>15</td></tr>
<tr><td>2010</td><td>128,000</td><td>85</td><td>15</td></tr>
<tr><td>2011</td><td>130,000</td><td>85</td><td>15</td></tr>
<tr><td>2012</td><td>130,000</td><td>85</td><td>15</td></tr>
<tr><td>2013</td><td>127,000</td><td>85</td><td>15</td></tr>
<tr><td>2014</td><td>89,000</td><td>85</td><td>15</td></tr>
<tr><td>2015</td><td>78,000</td><td>85</td><td>15</td></tr>
<tr><td>2016</td><td>66,000</td><td>85</td><td>15</td></tr>
<tr><td>2017</td><td>49,000</td><td>85</td><td>15</td></tr>
<tr><td>Trend</td><td></td><td colspan="5"></td></tr>
<tr><td>1990 – 2017</td><td>NA</td><td></td><td>-</td><td></td><td>-</td><td></td></tr>
<tr><td>2005 - 2017</td><td>NA</td><td></td><td>-</td><td></td><td>-</td><td></td></tr>
<tr><td>2016 - 2017</td><td>-25.8%</td><td></td><td>-</td><td></td><td>-</td><td></td></tr>
</table>

4.1.2.2.3 Choice of emission factors

Tier 1 is an output-based method and applies an emission factor to the total quantity of lime produced. The emission factor is based on the stoichiometric ratios.

The 2006 IPCC Guidelines Tier 1 approach[108] has been applied:

Equation 2.8: Tier 1 Default emission factor for lime production
(2006 IPCC Guidelines, Vol. 3, Chapter 2, sub-chapter 2.3.1.1)

$$\boldsymbol{EF_{Lime} = \frac{85\%}{100} \times EF_{high\ calcium\ lime} + \frac{15\%}{100} \times EF_{dolomitic\ lime}}$$

Where:

EF_{Lime} = emission factor for lime (tonnes CO_2 / tonne lime)

85% and 15% = default share of produced type of lime (%)

$EF_{high\ calcium\ lime}$ = emission factor for high-calcium lime (tonnes CO_2/tonne CaO)

$EF_{dolomitic\ lime}$ = emission factor for high-calcium lime (tonnes CO_2/tonne CaO·MgO)

[108] 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 2: Mineral Industry Emissions, Sub-chapter 2.3.1.1 Lime Production - Choice of method

Table 181 Basic parameters for the calculation of emission factors for lime production

Lime Type	Stoichiometric Ratio		Range of		Share (default)	CO_2 Emission factor (EF)		
	tonnes CO_2 / tonne CaO	tonnes CO_2 / CaO·MgO]	CaO Content	MgO Content		High-calcium lime	Dolomitic lime	Default lime
			%		%	(tonne CO_2 / t lime)		
High-calcium lime	0.785	-	93-98	0.3-2.5	85	0.75	-	-
Dolomitic lime	-	0.913	55-57	38-41	15	-	0.77	-
Default Lime								0.753

Source: Table 2.4 of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 2: Mineral Industry Emissions, sub-chapter 2.3.1.2 - Choice of emission factor (Lime Production)

4.1.2.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 2.A.2 Lime *production* are presented in the following table.

Table 182 Uncertainty for IPCC sub-category 2.A.2 Lime production.

Uncertainty	CO_2	Reference
• *Uncertainty in assuming an average CaO in lime*	*8%*	2006 IPCC GL, Vol. 3, Chap.2, Table 2.5 Default uncertainty values for lime production, page 2.25 and sub-chapter 2.3.2.2, page 2.26.
Activity data (AD)	10%	
• *Emission factor high calcium lime*	*2%*	2006 IPCC GL, Vol. 3, Chap.2, Table 2.5 Default uncertainty values for lime production, page 2.25 and sub-chapter 2.3.2.1, page 2.25.
• *Emission factor dolomitic lime*	*2%*	
Emission factor (EF)	3%	
Combined Uncertainty (U)	10%	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as Tier 1 approach is applied to the entire time series (1990 -2017).

4.1.2.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed:

⇒ Checked of calculations by spreadsheets
  - consistent use of production statistics from NSIA
  - documented sources,
  - use of units,
  - record keeping; use of write protection,
  - unique use of formulas; special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and US Geological Survey (USGS) Minerals Yearbook;

⇒ cross checks with other relevant sectors (sugar production) are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ emission factors check – IEF;

⇒ time series consistency - plausibility checks of dips and jumps.

4.1.2.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 2.A.2 Lime production.

Table 183 Recalculations done since submission 2017 IPCC sub-category 2.A.2 Lime production

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
2.A.2	Application of 2006 IPCC Guidelines	method	Accuracy Comparability
2.A.2	Application of default emission factors of 2006 IPCC Guidelines	EF	Accuracy Transparency

4.1.2.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.A.2	Investigation regarding lime production of the period 1990 – 2005	AD	Completeness	High
2.A.2	Analysis of lime types for application Tier 2	AD	Completeness	Medium
2.A.2	Analysis of industries that produce non-marketed, e.g. sugar production, pulp and paper manufacturing facilities, metallurgy, water softeners.	AD	Accuracy ,Transp arency	Medium
2.A.2	Percentage share in lime kiln dust (CKD) which is recycled	AD	Accuracy, Transparency	Medium

4.1.3 Glass Production (IPCC subcategory 2.A.3)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.A.3	Glass production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.A.3 *Glass Production* does not exist in Afghanistan.

4.1.4 Other Process Uses of Carbonates (IPCC subcategory 2.A.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.A.4	Other Process Uses of Carbonates	NO	-	NA	-	NA	-
2.A.4.a	Ceramics	NO	-	NA	-	NA	-
2.A.4.b	Other Uses of Soda Ash	NO	-	NA	-	NA	-
2.A.4.c	Non-Metallurgical Magnesia Production	NO	-	NA	-	NA	-
2.A.4.d	Other (please specify)	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.A.4 *Other Process Uses of Carbonates* does not exist in Afghanistan.

4.1.5 Other (IPCC subcategory 2.A.5)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.A.3	Other (please specify)	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.A.5 *Other* does not exist in Afghanistan.

4.2 Chemical Industry (IPCC category 2.B)

The IPCC category 2.B comprises the production of various inorganic and organic chemicals. The following tables provides information which of the chemical industries are occurrent in Afghanistan.

Table 184 Overview of chemical industries occurring in Afghanistan.

IPCC code	Description	Occurrent		Not occurrent NO
		Estimated	Not estimated (NE)	
2.B.1	Ammonia Production (*including Urea production*)	✓		
2.B.2	Nitric Acid Production		NE	
2.B.3	Adipic Acid Production			NO
2.B.4	Caprolactam, Glyoxal and Glyoxylic Acid Production			NO
2.B.5	Carbide Production			NO
2.B.6	Titanium Dioxide Production			NO
2.B.7	Soda Ash Production			NO
2.B.8	Petrochemical and Carbon Black Production			NO
2.B.8.a	Methanol			NO
2.B.8.b	Ethylene			NO
2.B.8.c	Ethylene Dichloride and Vinyl Chloride Monomer			NO
2.B.8.d	Ethylene Oxide			NO
2.B.8.e	Acrylonitrile			NO
2.B.8.f	Carbon Black			NO
2.B.9	Fluorochemical Production			NO
2.B.9.a	By product emissions			NO
2.B.9.b	Fugitive Emissions			NO
2.B.10	Other (Please specify)			NO

The *Kod-e-Barq* Fertilizer Plant in Mazar-e-Sharif is an integrated plant: The primary purpose of the ammonia production is the production of the feedstock NH_3 and CO_2 for the downstream process **urea production** and nitric acid production. The following figure provides an overview of the ammonia and urea production, as well as relevant other chemical processes.

The trend description of emissions from IPCC category 2.B Chemical Industry is provided in the following chapter 4.2.1 Ammonia Production (IPCC subcategory 2.B.1) as only one subcategory is occurring in Afghanistan.

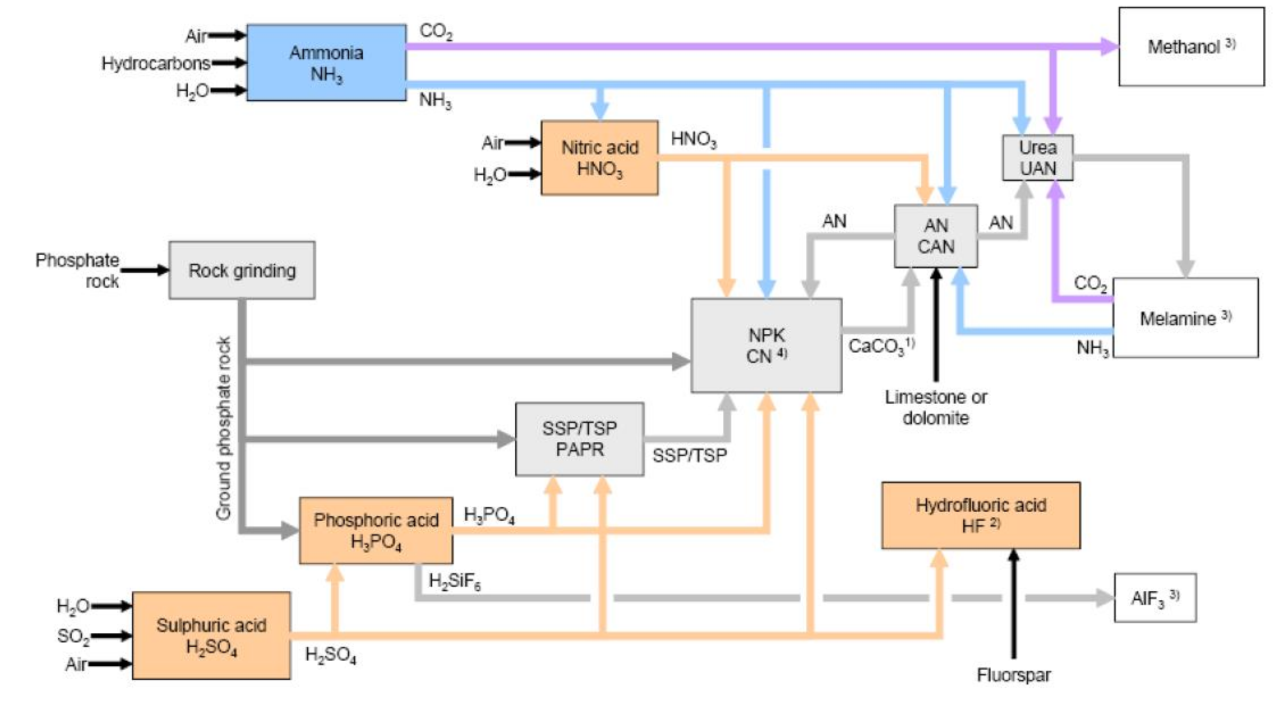


Figure I: Overview of boundaries and links between the LVIC-AAF industries
1) only with NPK production using the nitrophosphate route 2) not typically produced on fertiliser sites 3) not described in this document
4) CN is $Ca(NO_3)_2$, and is alternatively produced by neutralisation of HNO_3 with lime (not described in this document)

Figure 112 Example of integration of processes in the chemical industry

Source: EMEP/EEA air pollutant emission inventory guidebook 2016, Part B Sectoral Guidance Chapters, 2_IPPU, Chapter 2.B Chemical industry, Figure 2.2.[109]

[109] Available (18. January 2019) at https://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/2-industrial-processes/2-b-chemical-industry/2-b-chemical-industry-2016/view

4.2.1 Ammonia Production (IPCC subcategory 2.B.1)

4.2.1.1 Source category description

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.1	Ammonia production	✓	LA 1990, LA 2017, TA	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

This chapter includes the CO_2 emissions estimations from ammonia production. Process-related CO_2 emissions are released during ammonia production. Ammonia production is a key source with regards to CO_2 emissions.

Afghanistan has one ammonia plant which is mainly producing urea. The *Kod-e-Barq* Fertilizer Plant was built by the Soviet Union during the period from 1967 to 1973. It has a rated capacity of 200 tons per day of ammonia (through two lines of 100 tons/day) and 300 tons per day of urea (through three lines of 100 tons/day).[110]

The Fertilizer Plant uses a process technology that was abandoned in the 1950s using air separation for the production of nitrogen, while hydrogen is produced by low pressure steam reforming. The nitrogen and hydrogen so produced are synthesized to produce ammonia, which is then reacted with the carbon dioxide by-product to produce urea.[110]

The process of ammonia production is based on the ammonia synthesis loop (also referred to as the Haber-Bosch process) reaction of nitrogen (derived from process air) with hydrogen to form anhydrous liquid ammonia. The hydrogen is derived from feedstock as natural gas (conventional steam reforming route). Anhydrous ammonia produced by catalytic steam reforming of natural gas (mostly CH_4) involves the following reactions with carbon dioxide produced as a by-product:

Primary steam reforming	$CH_4 + H2O \rightarrow CO + 3H_2$
	$CO + H2O \rightarrow CO_2 + H_2$
Secondary air reforming	$CH_4 + air \rightarrow CO + 2H_2 + 2N_2$
Overall reaction	$0.88\ CH_4 + 1.26\ Air + 1.24H_2O \rightarrow 0.88CO_2 + N_2 + 3H_2$
Ammonia synthesis	$N_2 + 3H_2 \rightarrow 2NH_3$
Secondary reformer Process gas shift conversion	$CO + H_2O \rightarrow CO_2 + H_2$

[110] HILL INTERNATIONAL, INC. (2005): Evaluation of investment options for the development of oil and gas infrastructure in Afghanistan. Final Report. AFG/0361/TF 030397, Project No. PAG238/R BORHAN/REV.13; March 28, 2005, MAIN REPORT, Chapter 4.0 Task 1B – Gas Processing and Fertilizer Plants. Page 15. Available (16. January 2019) on https://de.scribd.com/document/90145031/Task1B

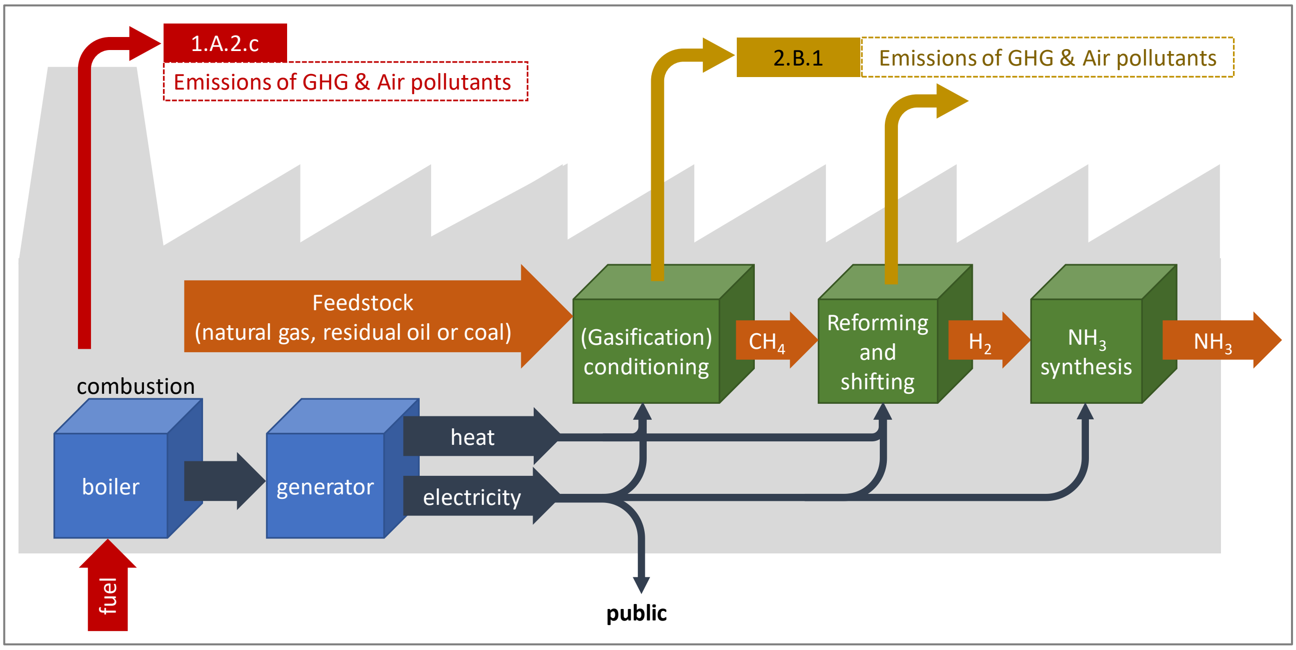


Figure 113 **Schematic scheme of ammonia production**

According to the 2006 IPCC Guidelines, the processes that affect CO_2 emissions associated with ammonia production are:

- carbon monoxide shift at two temperatures using iron oxide, copper oxide and/or chromium oxide catalyst for conversion to carbon dioxide;
- carbon dioxide absorption by a scrubber solution of hot potassium carbonate, monoethanolamine (MEA), Sulfinol (alkanol amine and tetrahydrothiophene dioxide) or others;
- methanation of residual CO_2 to methane with nickel catalysts to purify the synthesis gas.

Urea production

The urea production process consists of two main equilibrium reactions, with incomplete conversion of the reactants. The first is carbamate formation: the fast-exothermic reaction of liquid ammonia with gaseous carbon dioxide (CO_2) at high temperature and pressure to form ammonium carbamate (H2N-COONH4):

$$2NH_3 + CO_2 \leftrightarrows H_2N\text{-}COONH_4$$

The second is urea conversion - the slower endothermic decomposition of ammonium carbamate into urea and water:

$$H_2N\text{-}COONH_4 \leftrightarrows (NH_2)_2CO + H_2O$$

The overall conversion of NH3 and CO_2 to urea is exothermic, the reaction heat from the first reaction driving the second.

An overview of the GHG emission from ammonia production in IPCC sub-category 2.B.1. *Chemical industry* is provided in the following figure and table. The share in total GHG emissions from sector 2.B.1. is 0.9% for the year 1990, 0.6% for the year 2005, and 0.3% for the year 2017. The decrease and fluctuation of the GHG emissions are mainly due to

- fuel shortage[111] and/or unlimited extraction (2002 & 2003) and shortage of natural gas due to damaged and/or destroyed pipelines;
- power plant is in poor condition due to age of the plant (constructed in 1967 to 1973) and lack of sufficient resources for both routine maintenance and for the type of capital projects which most plants require through their lives for betterment, upgrades and partial replacement of equipment;[112]
- economic downturn due to the Afghan Civil War (1989–92, 1996–2001) and War in Afghanistan (2001–present).

As Afghanistan has only one fertilizer plant, therefor start-up and shut-down as well as maintenance periods are visible in the statistics.

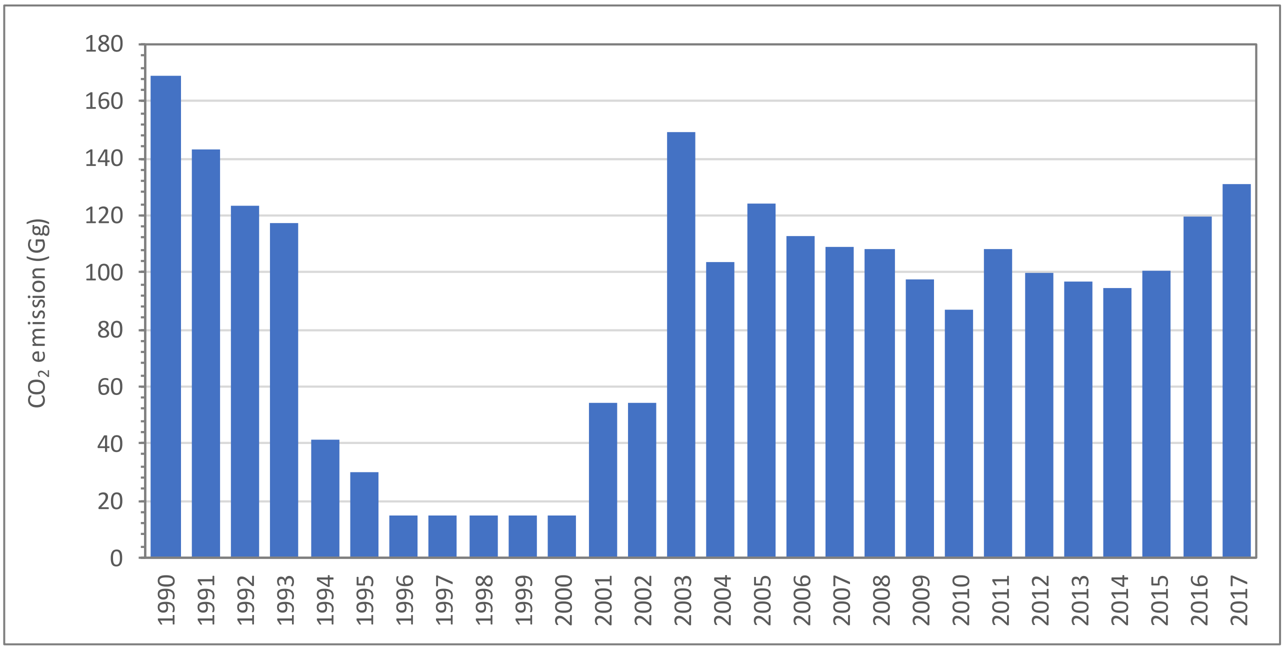


Figure 114 Emissions from IPCC sub-category 2.B.1 Ammonia Production

Table 185 CO_2 emissions from IPCC sub-category 2.B.1 Ammonia Production

	Process related CO_2 emissions 'estimated'	thereof	thereof	Combustion related CO_2 emissions (reported under IPCC 1.A.2.c)
		CO_2 emissions - ammonia for the market -	'calculated' CO_2 recovered for downstream use (only urea production)	
	Gg	Gg	Gg	Gg
1990	168.93	<0.001	42.15	218.44
1991	143.42	<0.001	35.77	233.41

[111] HILL INTERNATIONAL, INC. (2005): Evaluation of investment options for the development of oil and gas infrastructure in Afghanistan. Final Report. AFG/0361/TF 030397, Project No. PAG238/R BORHAN/REV.13; March 28, 2005, MAIN REPORT, Chapter 2.3 Status of Oil and Gas Infrastructure. Available (16. January 2019) on https://de.scribd.com/document/90145031/Task1B

[112] USAID (2011): Engineering support program. WO-LT-0024 Kud Bergh (Mazar) 48MW Power Plant Field Investigation Interim Report – Options for Refurbishment and Replacement of Power Plant – Addendum #1; April 21, 2011 Addendum #1: May 22, 2011. Washington. Available (16. January 2019) on https://files.globalwaters.org/water-links-files/Final%20Performance%20Evaluation%20-%20Afghan%20Engineering %20Support%20Program.pdf

	Process related CO_2 emissions 'estimated'	thereof CO_2 emissions - ammonia for the market -	thereof 'calculated' CO_2 recovered for downstream use (only urea production)	Combustion related CO_2 emissions (reported under IPCC 1.A.2.c)
	Gg	Gg	Gg	Gg
1992	123.48	<0.001	30.79	228.10
1993	117.53	<0.001	29.32	222.63
1994	41.30	<0.001	10.26	294.40
1995	29.57	<0.001	7.33	294.35
1996	14.70	<0.001	3.67	297.35
1997	14.70	<0.001	3.67	272.12
1998	14.70	<0.001	3.67	251.93
1999	14.70	<0.001	3.67	231.75
2000	14.83	<0.001	3.67	211.39
2001	54.12	<0.001	13.49	150.32
2002	54.12	<0.001	13.49	495.12
2003	149.41	<0.001	37.31	301.69
2004	103.46	<0.001	25.82	116.49
2005	124.19	<0.001	31.01	194.95
2006	112.46	<0.001	28.07	197.11
2007	108.68	<0.001	27.12	182.52
2008	108.33	<0.001	27.05	170.60
2009	97.86	<0.001	24.42	158.48
2010	86.96	<0.001	21.68	169.69
2011	108.42	<0.001	27.00	182.68
2012	100.04	<0.001	24.85	189.66
2013	96.70	<0.001	24.05	182.52
2014	94.67	<0.001	23.58	161.31
2015	100.51	<0.001	25.03	163.01
2016	119.33	<0.001	29.83	178.31
2017	130.67	<0.001	32.67	158.09
Trend				
1990 - 2017	*-22.6%*	*-100.0%*	*-22.5%*	*-27.3%*
2005 - 2017	*-3.9%*	*-100.0%*	*-3.8%*	*-8.3%*
2016 - 2017	*9.5%*	*NA*	*9.5%*	*-10.2%*

4.2.1.2 Methodological issues

4.2.1.2.1 Choice of methods

Ammonia production

For estimating the CO_2 emissions, the 2006 IPCC Guidelines Tier 1 approach[113] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{CO_2} = AP \times FR \times CCF \times COF \times \frac{44}{12} - R_{CO_2}}$$

Where:

Emissions $_{CO2}$	= CO_2 emission (kg)
FR	= ammonia production (tonnes)
FR	= fuel requirement per unit of output (GJ/tonne ammonia produced)
CCF	= carbon content factor of the fuel (kg C/GJ)
COF	= carbon oxidation factor of the fuel, fraction
R_{CO2}	= CO_2 recovered for downstream use (urea production) (kg)

For estimating the air pollutants emissions (NO_x, CO, NMVOC, SO_2) the Tier 1 approach[114] of the EMEP/EEA air pollutant emission inventory guidebook 2016 has been applied:

Air pollutant emissions from ammonia production

$$\boldsymbol{Emissions_{pollutant} = Production\ data \times Emission\ Factor_{pollutant}}$$

Where:

Emissions $_{pollutant}$	= emissions of a given pollutant by type of fuel (kg pollutant)
Production data	= Ammonia production (tonnes)
Emission factor $_{pollutant}$	= default emission factor of a given pollutant by type of fuel (kg $_{pollutant}$/t $_{NH3}$).
Pollutant	= NOx, CO, NMVOC

Urea production

Emissions from urea production are unlikely to be significant in well-managed modern plants, it is *good practice* to obtain plant-level information on urea production and to account for any significant emissions: based on typical inputs for modern plants, the input values imply that emissions of CO_2 range from 2 to 7kg per tonne of urea. For a plant of 1 000 tonnes of urea per day and assuming capacity utilization of around 90 percent, this would imply annual emissions of CO_2 of slightly in excess of 2Gg. [115]

As the total ammonia production was not available but the total urea production and natural gas consumption for both combustions related and as feedstock (process related), a 'backwards calculation' applying the methodology described above made. In Table 186 all formula, activity data and parameter used are presented and for the year 2015 applied.

[113] Source: 2006 IPCC Guidelines, Volume 3: IPPU, Chapter 3: Chemical Industry Emissions – 3.2.2.1 Choice of method

[114] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, Chap. 2.B Chemical industry, sub-chapter 3.2 Tier 1 default approach.

[115] Source: 2006 IPCC Guidelines, Volume 3: IPPU, Chapter 3: Chemical Industry Emissions – 3.2.2.3 Choice of activity data, Box 3.

4.2.1.2.2 Choice of activity data

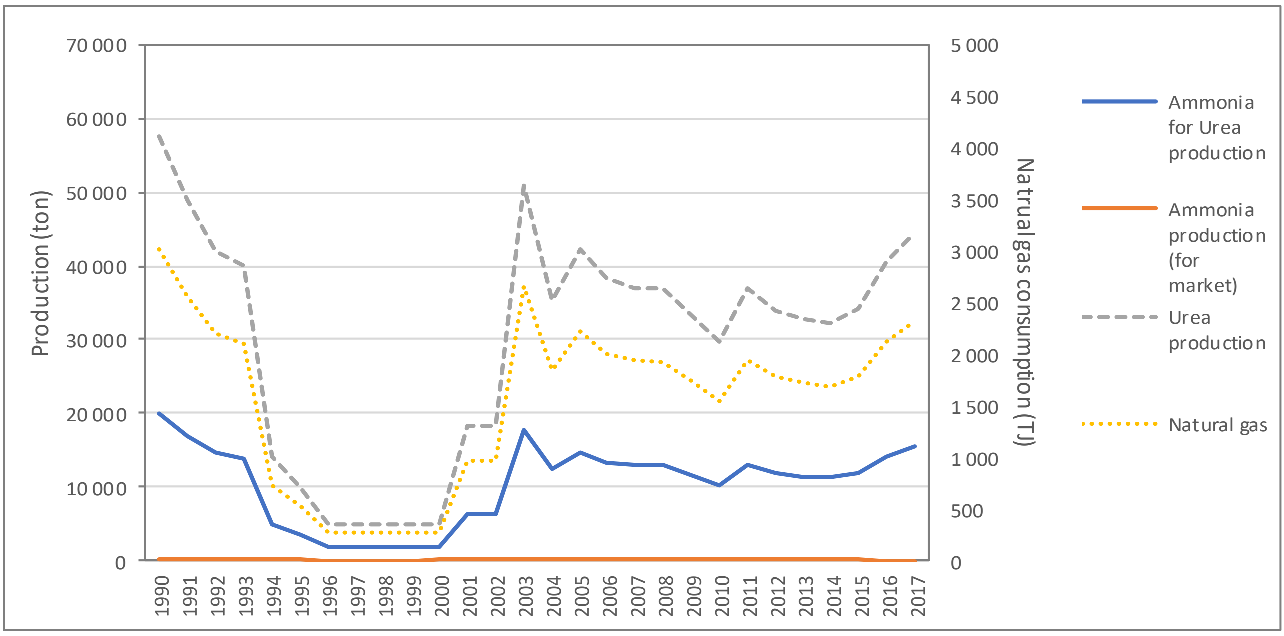


Figure 115 Activity data for IPCC sub-category 2.B.1 Ammonia Production

The data of urea production are taken from two sources:

- 2008 – 2017 from National Statistics and Information Authority (NSIA), National Statistical Yearbook (various years), Table 9-5: Government Industrial and Mining Production by Kind of Product
- 1990 – 2007 from FAO statistics - Fertilizers by Product[116]
  - 2004 – 2002 Official data from questionnaires and/or national sources and/or COMTRADE
  - 1990 – 2002 Unofficial figure

The data on ammonia production (Liquid Ammonia) are taken from two sources:

- 2007 – 2017 from National Statistics and Information Authority (NSIA), Statistical yearbook National Statistical Yearbook (various years) Table 9-12: Quantity and Value of Mining and Quarrying
- 1990 – 2006 from British Geological Survey (BGS)(several years).[117]

In Table 186 the ammonia production is labeled as 'ammonia production market'.

The data on natural gas consumption (combustion and feedstock) are for the years:

- 2006 – 2017 from National Statistics and Information Authority (NSIA), Table 9-13: Quantity and Value of Mining and Quarrying and National Statistical Yearbook (various years)
- 1990 – 2004 from the UN Statistics Division (UNSD) - Energy Statistics Section. [118]

The Gross caloric factor (GCV) is taken from the 'Gas documentation' provided by the International Energy Agency (IEA)(2018)[119]. According to national experts of Ministry of Mining and Petroleum (MoMP), Ministry of Energy and Water (MEW) and University of Kabul, the GCV of natural gas of Turkmenistan is similar.

As no information was available regarding the quantity of feedstock used in the ammonia plant a theoretical

[116] Food and Agriculture Organization (FAO) (2019): Available (16. January 2019) on http://www.fao.org/faostat/en/#data/RFB

[117] British Geological Survey (BGS)(2019): Available (16. January 2019) on https://www.bgs.ac.uk/mineralsuk/statistics/worldArchive.html

[118] UNSTATS (2019): Available (16. January 2019) on https://unstats.un.org/unsd/energy/default.htm

[119] International Energy Agency (IEA)(2019): Available (16. January 2019) on https://www.iea.org/statistics/resources/documentation/

split was made based on the following assumption.

⇒ 36% Feedstock (process related natural gas consumption): 'Assumed' process feedstock

Assuming that 4 times of the 'calculated' feedstock used for the urea production is consumed in the fertilizer plant.

- Process efficiency, start-ups and shut-downs as well as maintenance periods are not known
- start-ups and shut-downs lead to higher consumption and emissions
- poor condition of plant
- Quantity of nitric acid production is not known (downstream)
- Further downstream processes are not known

⇒ 64% Consumption of natural gas for production of heat and electricity

It is ensured that no double counting or omission of natural gas input and emissions happened.

The default total fuel requirements (fuel plus feedstock) and emission factors for ammonia production taken from the 2006 IPCC guidelines[120] were applied:

- fuel requirement per unit of output (produced);
- carbon content factor of the fuel;
- carbon oxidation factor of the fuel;
- conversion factor of carbon in carbon dioxide;
- urea conversion of NH_3 and CO_2 to urea ($CO(NH_2)_2$).

The IPCC default CO_2 emission factors for stationary combustion in manufacturing industries and construction[121] was applied for the combustion process.

The urea production decreased by 23% in the period 1990 - 2017 and increased by 5% in the period 2005 - 2017. From 2016 to 2017 the natural gas consumption increased by 9% due to decreasing efficiency of the fertilizer plant. As mentioned above, the fluctuation of the fuel consumption is mainly due

- fuel shortage[111] and/or unlimited extraction (2002 & 2003)
- power plant is in poor condition due to age of the plant (constructed in 1967 to 1973) and lack of sufficient resources for both routine maintenance and for the type of capital projects which most plants require through their lives for betterment, upgrades and partial replacement of equipment;[112]
- shortage of natural gas due to damaged and/or destroyed pipelines;
- economic downturn due to the Afghan Civil War (1989–92, 1996–2001) and War in Afghanistan (2001–present).

As Afghanistan has only one fertilizer plant, start-up, shut-down and maintenance periods are easily visible in the statistics.

In a 'backwards calculation' relevant activity data and parameters which were not available were estimated using default parameter from the 2006 IPCC Guidelines, Vol. 3, Chapter 3. In Table 186 all formula, activity data and parameter used are presented and for the year 2015 applied.

[120] Source: 2006 IPCC Guidelines, Volume 3: IPPU, Chapter 3: Chemical Industry Emissions – 3.2.2.2 Choice of method, Table 1

[121] 2006 IPCC Guidelines, Volume 2, Chapter 2, Table 2.3 Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)

Table 186 'Backwards calculation' of IPCC sub-category 2.B.1 Ammonia production

	Parameter	Parameter description	Unit	Formula	2015	Source
L1	**UP**	**Amount of Urea Produced**	**tonnes**		**34 141**	NSIA, FAO & UN
L2	$Conv_{NH3-Urea}$	conversion of NH_3 and CO_2 to urea ($CO(NH_2)_2$)			0.733	Box 3.3, 2006 IPCC GL, Vol. 3, Chap. 3
L3	**cR_{CO2}**	**'calculated' CO_2 emissions recovered for downstream use (urea production)**	**tonnes CO_2**	**=UP * cR_{CO2}**	**25 025**	Box 3.3, 2006 IPCC GL, Vol. 3, Chap. 3
L4	FR	fuel requirement per unit of output (produced)	GJ/tonne NH_3		37.5	Table 3.1, 2006 IPCC GL, Vol. 3, Chap. 3
L5	CCF	carbon content factor of the fuel	kg C/GJ		15.3	Table 3.1, 2006 IPCC GL, Vol. 3, Chap. 3
L6	COF	carbon oxidation factor of the fuel	fraction		1	Table 3.1, 2006 IPCC GL, Vol. 3, Chap. 3
L7	con	Conversion factor of carbon in carbon dioxide	-	=(44/12)	3.67	Table 3.1, 2006 IPCC GL, Vol. 3, Chap. 3
L8	**$EF_{CO2\_process}$**	**CO_2 emission factor**	**kg CO_2 /tonne NH_3**	**=FR * CCF * COF * con**	**2.104**	Equation 3.1, 2006 IPCC GL, Vol. 3, Chap. 3
L9	AP_{cal}	ammonia production 'calculated' (based on urea production)	tonnes	$=cRCO_2 / EF_{CO2}$	11 896	Equation 3.1, 2006 IPCC GL, Vol. 3, Chap. 3
L10	AP_{mar}	ammonia production market	tonnes		49	NSIA, BGS
L11	**AP_{TOTAL}**	**TOTAL ammonia production ('assumed')**	**tonnes**	**= AP_{cal} + AP_{mar}**	**11 944**	
L12	$C_{Fuel\_APcal\_GJ}$	calculated feedstock - ammonia production for urea	GJ	=FR * AP_{cal}	447 907	Table 3.1, 2006 IPCC GL, Vol. 3, Chap. 3
L13	$C_{Fuel\_APcal\_TJ}$	calculated feedstock - ammonia production for urea	TJ	=C_{Fuel_APcal} / 1000	448	
L14	C_{Fuel_APmar}	calculated feedstock - ammonia market	GJ	=FR * AP_{mar}	1 822.5	Table 3.1, 2006 IPCC GL, Vol. 3, Chap. 3
L15	C_{Fuel_APmar}	calculated feedstock - ammonia market	TJ	=C_{Fuel_APmarl} / 1000	1.82	
L16	$C_{Fuel\_APtotal\_GJ}$	calculated feedstock - TOTAL	GJ	=FR * AP_{TOTAL}	449 730	
L17	**$C_{Fuel\_APtotal\_TJ}$**	**calculated feedstock - TOTAL**	**TJ**	**=$C_{Fuel\_APtotal}$ / 1000**	**450**	
L18	**$EB\_Cons_{gas\_vol}$**	**Total Natural gas consumption (volume)**	**million m^3**		**146.2**	**NSIA/UN**
L19	GCV	Gross caloric factor (GCV)	TJ / m^3		37 889	IEA (2018); value of Turkmenistan
L20	NCV	Net caloric factor (GNCV)	TJ / m^3	=0.9*GCV	34 100	
L21	$EB\_Cons_{gas\_net\_GJ}$	Total Natural Gas Consumption	GJ	=$EB\_Cons_{gas\_vol}$ *NCV	4 985 435	

	Parameter	Parameter description	Unit	Formula	2015	Source
L22	**$EB\_Cons_{gas\_net\_TJ}$**	**Total Natural Gas Consumption**	**TJ**	**$=EB\_Cons_{gas\_vol}$ *NCV*10-3**	**4 985**	**calculated**
L23	Share_theor	Theoretical share of 'calculated feedstock - Urea production' - process feedstock	%	$=C_{Fuel\_APcal\_TJ}/EB\_Cons_{gas\_net\_TJ}$	9.0%	
L24	**$EB\_Cons_{gas\_process\_TJ}$**	**feedstock (process related fuel consumption):** 'Assumed' process feedstock - 4 times of 'calculated feedstock - Urea production'	**TJ**	**$=4* C_{Fuel\_APtotal\_TJ}$**	**1 792**	Assumption due to • Downstream process nitric acid, urea, etc. • start-up, shut down, maintenance • poor condition of plant
L25	Share_assume	'Assumed' share of 'calculated feedstock - Urea production' - process feedstock	%	=4* Share_theor	36.0%	
L26	**$EB\_Cons_{gas\_comb\_TJ}$**	**Combustion related fuel consumption** = Total Natural Gas Consumption - feedstock (process related fuel consumption)	**TJ**	**$= EB\_Cons_{gas\_net\_TJ}$ $- EB\_Cons_{gas\_process\_TJ}$**	**3 194**	Reported in 1.A.2.c
L27	EF $CO_{2\ gas}$	CO_2 emission factor combustion	kg CO_2/ TJ		56 100	Table 2.3, 2006 IPCC GL, Vol. 2, Chap. 2
L28	**$E_{CO2\_process}$**	**CO_2 - Process related Natural Gas Consumption (feedstock) - ammonia production for urea**	**Gg**	**$=EF\ CO_{2\text{-}gas}*EB\_Cons_{gas\_comb\_TJ}$**	**101**	**Reported in 2.B.1**
L29	E_{CO2}	CO_2 - Combustion related Natural Gas Consumption	Gg	$=EF\ CO_{2\text{-}gas}*EB\_Cons_{gas\_comb\_TJ}$	179	Reported in 1.A.2.c
	Downstream					
L30	**E_{CO2_market}**	**CO_2 emissions - ammonia market**	**Gg**	**$=AP * EF_{CO2\_process}$**	**$102*10^{-9}$**	Equation 3.1, 2006 IPCC GL, Vol. 3, Chap. 3
L31	**cR_{CO2}**	**'calculated' CO_2 emission recovered for downstream use (urea production)**	**Gg**	**$= cR_{CO2}$ /1000**	**25**	

Table 187 Activity data - Ammonia and Urea production - for IPCC sub-category 2.B.1 Ammonia Production

Activity data 2.B.1	'Estimated' total Ammonia production	Amount of Ammonia used for					Urea Production	
		Urea production (calculated)	*For market*		*Nitric Acid production*	*Other*		
			(calculated)	*Source*				
	tons						tons	Source
1990	20 074	20 034	40	BGS	NE	NE	57 500	FAO/ UNDS
1991	17 043	17 003	40		NE	NE	48 800	
1992	14 674	14 634	40		NE	NE	42 000	
1993	13 967	13 937	30		NE	NE	40 000	
1994	4 908	4 878	30		NE	NE	14 000	
1995	3 514	3 484	30		NE	NE	10 000	
1996	1 747	1 742	5		NE	NE	5 000	
1997	1 747	1 742	5		NE	NE	5 000	
1998	1 747	1 742	5		NE	NE	5 000	
1999	1 747	1 742	5		NE	NE	5 000	
2000	1 762	1 742	20		NE	NE	5 000	
2001	6 431	6 411	20		NE	NE	18 400	
2002	6 431	6 411	20		NE	NE	18 400	
2003	17 755	17 735	20		NE	NE	50 900	
2004	12 295	12 275	20		NE	NE	35 230	
2005	14 758	14 738	20		NE	NE	42 300	
2006	13 365	13 345	20		NE	NE	38 300	NSIA
2007	12 915	12 892	23	NSIA	NE	NE	37 000	
2008	12 874	12 856	18		NE	NE	36 897	
2009	11 629	11 607	22		NE	NE	33 314	
2010	10 333	10 306	27		NE	NE	29 579	
2011	12 885	12 834	51		NE	NE	36 834	
2012	11 889	11 813	76		NE	NE	33 904	
2013	11 491	11 431	60		NE	NE	32 807	
2014	11 250	11 207	44		NE	NE	32 164	
2015	11 944	11 896	49		NE	NE	34 141	
2016	14 181	14 181	NO		NE	NE	40 700	
2017	15 528	15 528	NO		NE	NE	44 566	
Trend								
1990 - 2017	*-23%*	*-23%*	*-100%*		-	-	*-23%*	
2005 - 2017	*5%*	*5%*	*-100%*		-	-	*5%*	
1990 - 2017	*9%*	*9%*	-		-	-	*9%*	

Table 188 Activity data - Natural Gas - for IPCC sub-category 2.B.1 Ammonia Production & 1.A.2.c Chemical industry

Activity data	Total natural gas supply	Process related fuel consumption of Natural gas - feedstock 'estimated'			Combustion related CO_2 emissions
		Natural gas *(calculated)*	'calculated' for downstream use (only urea production)	- ammonia for the market -	Gaseous fuels *(calculated)*
		Reported in 2.B.1			Reported in 1.A.2.c
	TJ				
1990	7 350	3 011	753	1.50	4 339
1991	7 128	2 556	639	1.50	4 572
1992	6 636	2 201	550	1.50	4 435
1993	6 417	2 095	524	1.13	4 322
1994	6 147	736	184	1.13	5 411
1995	5 895	527	132	1.13	5 368
1996	5 625	262	66	0.19	5 363
1997	5 175	262	66	0.19	4 913
1998	4 815	262	66	0.19	4 553
1999	4 455	262	66	0.19	4 193
2000	4 095	264	66	0.75	3 831
2001	3 825	965	241	0.75	2 860
2002	10 009	965	241	0.75	9 044
2003	8 499	2 663	666	0.75	5 835
2004	4 179	1 844	461	0.75	2 334
2005	6 040	2 214	553	0.75	3 826
2006	5 848	2 005	501	0.75	3 843
2007	5 505	1 937	484	0.86	3 568
2008	5 279	1 931	483	0.67	3 348
2009	4 849	1 744	436	0.82	3 105
2010	4 839	1 550	388	1.02	3 289
2011	5 504	1 933	483	1.90	3 571
2012	5 466	1 783	446	2.84	3 683
2013	5 268	1 724	431	2.25	3 545
2014	4 839	1 688	422	1.64	3 151
2015	4 985	1 792	448	1.82	3 194
2016	5 637	2 127	532	0.00	3 510
2017	5 482	2 329	582	0.00	3 153
Trend					
1990 - 2017	*-25%*	*-23%*	*-23%*	*-100%*	*-27%*
2005 - 2017	*-7%*	*5%*	*-4%*	*-100%*	*-8%*
1990 - 2017	*-3%*	*9%*	*9%*	*-100%*	*-10%*

4.2.1.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 189 GHG Emission factor TIER 1 for IPCC sub-category 2.B.1 Ammonia Production

Fuel	CO_2 (kg CO_2 /tonne NH3)		CH_4		N_2O		Source
	EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 3, Chap. 3
Derived from European average values for specific energy consumption (Mix of modern and older plants) Average value – natural gas	2.104	D	NA	D	NA	-	**Table 3.1,** Chap. 3.2.2.2 based on **Equation 3.1**, Chap. 3.2.2.2

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

Default emission factors for air pollutant were taken from the EMEP/EEA air pollutant emission inventory Guidebook 2016[122] and are presented in the following table.

Table 190 Non-GHG Emission factor for IPCC sub-category 2.B.1 Ammonia production

Fuel	Fuel type	NOx (kg/t NH3)		CO (kg/t NH3)		NMVOC (kg/t NH3)		SO_2 (kg/t NH3)		Source
		EF	type	EF	type	EF	type	EF	type	EMEP/EEA Guidebook 2016, Part B, IPPU, 2.B Chemical industry
Natural gas	gaseous	1	D	0.1	D	NA	-	NA	-	**Table 3.2** Tier 1 emission factors for source category 2.B.1 Ammonia production. (page. 14)

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

4.2.1.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.2.c Chemical industry are presented in the following table.

Table 191 Uncertainty for IPCC sub-category 2.B.1 Ammonia production.

Uncertainty	Liquid fuels	Reference
	CO_2	2006 IPCC GL, Vol. 2, Chap. 2 (2.4.2) 2006 IPCC GL, Vol. 3, Chap. 3 (3.2.3)
Activity data (AD)	10%	Table 2.15 and Table 3.1
Emission factor (EF)	10%	Table 3.1
Combined Uncertainty (U)	14%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

[122] Available (16. December 2018) on https://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/2-industrial-processes

4.2.1.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets;
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources: national statistic, BGS, energy statistics of UN and FAO;

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

4.2.1.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category 1.A.2.c *Chemical industry* and 2.B.1 *Ammonia production.*

Table 192 Recalculations done since SNC in IPCC sub-category 2.B.1 Ammonia production

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.2.c 2.B.2	Consumption of natural gas (activity data) for ammonia plant was completely allocate in 1.A.2.m. It was also assumed that the • entire amount of natural gas was burned; • no natural gas was used as feedstock (non-energy use); • no CO_2 recovery for downstream process – urea production.	AD	Accuracy Transparency Comparability
1.A.2.c 2.B.2	Reallocation of fuel consumption (natural gas, solid fuels) to relevant subcategories – 1.A.2	AD	Transparency Comparability
1.A.2.c 2.B.2	use of default NCV of 2006 IPCC Guidelines	AD	Comparability
1.A.2.c 2.B.2	use of default EF of 2006 IPCC Guidelines	EF	Comparability
1.A.2.c 2.B.2	application of 2006 IPCC Guidelines	method	Comparability

4.2.1.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 193 Planned improvements for IPCC sub-category 2.B.1 Ammonia production

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.c 2.B.1	Analysis of interdependency of different inorganic chemical processes of the fertilizer plant (see figure #)	AD EF	Completeness Transparency	high
1.A.2.c 2.B.1	Survey on fuel used (natural gas, liquid fuels etc.) in power plant: • annual amount of fuel consumption for combustion • annual amount of feedstock / Total fuel requirement (GJ(NCV)/tonne NH3)	AD	Completeness Transparency	high
1.A.2.c 2.B.1	Cross-check of national and international data sources and feedback to UNSD	AD	Consistency Transparency	medium
1.A.2.c 2.B.1	Country specific Net Caloric Value (NCV) for used fuels: natural gas ⇒ conversion from mass unit to energy unit (unit EF is kg /TJ)	AD EF	Accuracy Transparency	medium
1.A.2.c 2.B.2	Carbon content (%) of used fuels - natural gas etc. - for preparing country specific emission factor (CS EF) ⇒ **CS EF_{CO2}** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	medium
1.A.2.c	Sulphur content in used fuel for preparing country specific emission factor (CS EF) ⇒ **CS EF_{SO2}** [g/GJ] = (S [%] • 20000) / (NCV [GJ/t])	EF non-GHG	Accuracy Transparency	medium
1.A.2.c	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF non-GHG	Accuracy Transparency	medium
1.A.2.c	Data obtained from measurements made on the emission of air polluters (NON-GHG inventory) • Determination of the temperature in waste gases [°C]; • Determination of the static pressure and the dynamic pressure [kPa]; • Determination of the flow rate [m/s]; • Determination of volume flow rate [m^3/h and Nm^3/h]; • Determination of the concentration of CO, SO_2, NOx in the exhaust gases [mg/Nm^3]; and • Gravimetric extraction of solid particles (TSP) from gases and determination by applying a gravimetric method (mg/Nm^3).	EF non-GHG	Accuracy Transparency	medium

4.2.2 Nitric Acid Production (IPCC subcategory 2.B.2)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.2	Nitric Acid Production	NA	-	NA	-	NE	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

Nitric Acid Production in general is part of the fertilizer plant. The emissions of nitric acid production are not estimated as no production data were available.

4.2.2.1 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 194 Planned improvements for IPCC sub-category 2.B.2 Nitric Acid Production

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.c 2.B.2	Analysis of interdependency of different inorganic chemical processes of the fertilizer plant (see Figure 112)	AD	Completeness Transparency	high
2.B.2	Survey on annual quantity of nitric acid production	AD	Completeness Transparency	high
1.A.2.c 2.B.2	Survey on fuel used (natural gas, liquid fuels etc.) in power plant: • annual amount of fuel consumption for combustion • annual amount of feedstock / Total fuel requirement (GJ(NCV)/tonne NH3)	AD	Completeness Transparency	high

4.2.3 Adipic Acid Production (IPCC subcategory 2.B.3)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.3	Adipic Acid Production	NO	-	NA	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.B.3 *Adipic Acid Production* does not exist in Afghanistan.

4.2.4 Caprolactam, Glyoxal and Glyoxylic Acid Production (IPCC subcategory 2.B.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.4	Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	-	NA	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.B.4 *Caprolactam, Glyoxal and Glyoxylic Acid Production* does not exist in Afghanistan.

4.2.5 Carbide Production (IPCC subcategory 2.B.5)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.5	Carbide Production	NO	-	NO	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.B.5 *Carbide Production* does not exist in Afghanistan.

4.2.6 Titanium Dioxide Production (IPCC subcategory 2.B.6)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.6	Titanium Dioxide Production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.B.6 *Titanium Dioxide Production* does not exist in Afghanistan.

4.2.7 Soda Ash Production (IPCC subcategory 2.B.7)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.7	Soda Ash Production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.B.7 *Soda Ash Production* does not exist in Afghanistan.

4.2.8 Petrochemical and Carbon Black Production (IPCC subcategory 2.B.8)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.8	Petrochemical and Carbon Black Production	NO	-	NO	-	NA	-
2.B.8.a	Methanol	NO	-	NO	-	NA	-
2.B.8.b	Ethylene	NO	-	NO	-	NA	-
2.B.8.c	Ethylene Dichloride and Vinyl Chloride Monomer	NO	-	NO	-	NA	-
2.B.8.d	Ethylene Oxide	NO	-	NO	-	NA	-
2.B.8.e	Acrylonitrile	NO	-	NO	-	NA	-
2.B.8.f	Carbon Black	NO	-	NO	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.B.8 *Petrochemical and Carbon Black Production* does not exist in Afghanistan.

4.2.9 Fluorochemical Production (IPCC subcategory 2.B.9)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.9	Fluorochemical Production	NA	-	NA	-	NA	-
2.B.9.a	By product emissions	NA	-	NA	-	NA	-
2.B.9.b	Fugitive Emissions	NA	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.B.9 *Fluorochemical Production* does not exist in Afghanistan.

4.2.10 Other (IPCC subcategory 2.B.10)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.10	Other	NO	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.B.10 *Other* does not exist in Afghanistan.

4.3 Metal Industry (IPCC category 2.C)

The IPCC category 2.C comprises the production of various ferrous and non-ferrous producing industries, where GHG emissions are arising. No GHG emissions arise from IPCC category 2.C *Metal Industry* as this sector does not exist in Afghanistan. GHG emissions from secondary metal industry are reported in IPCC category 1.A.2 *Manufacturing Industries and Construction.*

4.3.1 Iron and Steel Production (IPCC subcategory 2.C.1)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.1	Iron and Steel Production	NO	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.C.1 *Iron and Steel Production* does not exist in Afghanistan.

In Afghanistan, the iron and steel industry produce steel from recycled steel scrap – secondary iron production. The steel production takes place in electric induction furnaces - high frequency induction furnace with temperature of up to 1600 – 1700 °C. The charge of the furnace is 100 % steel scrap and no carbon electrodes are added. No GHG emission arise from this category.

4.3.2 Ferroalloys Production (IPCC subcategory 2.C.2)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.2	Ferroalloys Production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.C.2 *Ferroalloys Production* does not exist in Afghanistan.

4.3.3 Aluminum Production (IPCC subcategory 2.C.3)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.3	Aluminium production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.C.3 *Aluminum Production* does not exist in Afghanistan.

4.3.4 Magnesium Production (IPCC subcategory 2.C.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.4	Magnesium production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.C.4 *Magnesium Production* does not exist in Afghanistan.

4.3.5 Lead Production (IPCC subcategory 2.C.5)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.5	Lead Production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.C.5 *Lead Production* does not exist in Afghanistan.

4.3.6 Zinc Production (IPCC subcategory 2.C.6)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.6	Zinc Production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.C.6 *Zinc Production* does not exist in Afghanistan.

4.3.7 Other (IPCC subcategory 2.C.7)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.7	Other (please specify)	NO	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.C.7 *Other* does not exist in Afghanistan.

4.4 Non-Energy Products from Fuels and Solvent Use (IPCC category 2.D)

The IPCC category 2.D comprises the non-energy products use such as lubricants, paraffin waxes, and bitumen/asphalt, as well as solvents uses where GHG emissions are arising.

The IPCC category 2.D does not cover emissions from the first use of fossil fuels as a product for primary purposes other than

i) combustion for energy purposes	accounted for in IPCC category 1.A. Fuel Combustion activities
ii) use as feedstock or reducing agent	accounted for in IPCC sub-category 2.B. Chemical industry and in IPCC sub-category 2.C. Metal industry

4.4.1 Lubricant Use (IPCC subcategory 2.D.1)

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.

4.4.1.1 Source category description

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.D.1	Lubricant Use	✓	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The use of lubricants was responsible for about 14% of GHG emissions in CO_{2eq} from industrial processes in 2017 and 1990 and for less than 14% of the total CO_2 emissions estimated in 2017 and 1990. It represented less than 0.2% of the total GHG emissions in 1990 and 217. The CO_2 emission are for the entire period 1990 – 2017 on a constant level of 33.41 Gg CO_2.
An overview of the *Lubricant Use* (IPCC sub-category 2.D.1) related CO_2 emissions is provided in the following figure and table.

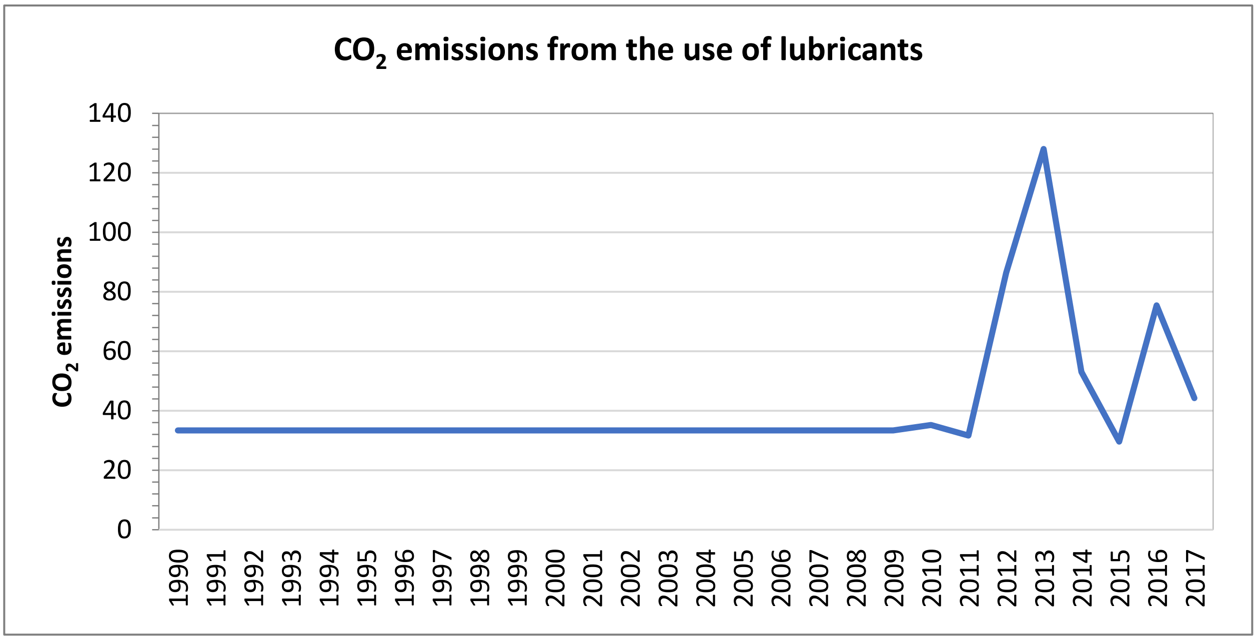


Figure 116 CO_2 emissions from IPCC sub-category 2.D.1 Lubricant Use 1990-2017

Table 195 CO_2 emissions from Lubricant Use (IPCC sub-category 2.D.1)

Years	CO_2 emission
	Gg
1990	33.41
1991	33.41
1992	33.41
1993	33.41
1994	33.41
1995	33.41
1996	33.41
1997	33.41
1998	33.41
1999	33.41
2000	33.41
2001	33.41
2002	33.41
2003	33.41
2004	33.41
2005	33.41
2006	33.41
2007	33.41
2008	33.41
2009	33.41
2010	35.17
2011	31.65
2012	86.39

Years	CO_2 emission
	Gg
2013	128.01
2014	53.11
2015	29.58
2016	75.46
2017	44.24
Trend	
1990 – 2017	*32.4%*
2005 - 2017	*32.4%*
2016 - 2017	*-41.4%*

4.4.1.2 Methodological issues

4.4.1.2.1 Choice of methods

The 2006 IPCC Guidelines Tier 1 approach[123] has been applied:

Equation 5.2: Tier 1 - Lubricants
(2006 IPCC GL, Vol. 3, Chap. 5.2.2.1)

$$CO_2\ emissions = LC \times CC_{lubricant} \times ODU_{\mathrm{lubricant}} \times \frac{44}{12}$$

Where:

CO_2 Emissions = emissions of CO_2 from lubricants (tonnes)
LC = total lubricant consumption (TJ)
$CC_{lubricant}$ = (default) carbon content of lubricants (tonne C/TJ) (= kg C/GJ)
$ODU_{Lubricant}$ = ODU factor (based on default composition of oil and grease) (fraction)
44/12 = Conversion factor for mass ratio of CO_2/C

4.4.1.2.2 Choice of activity data

The data used in the inventory are based on import and export data provided for the years

- 2010 – 2017 by National Statistics and Information Authority (NSIA)
- 2009 Average of the years 2010 and 2011.

  The original data provided in the import /export statistics for 2009 are quite low. Lubricants are necessary for running vehicles, especially 2 stroke machines. Therefore, an average is applied.
- 1990 – 2008 As not data was available for the period, the value of 2009, which is an average of the years 2010 und 2011.

In the following figures and table, the activity data are presented.

[123] Source: 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 5: Non-Energy Products from Fuels and Solvent Use, Sub-chapter 5.2.2.1 Choice of methods (5.2 LUBRICANT USE). Page 5.7

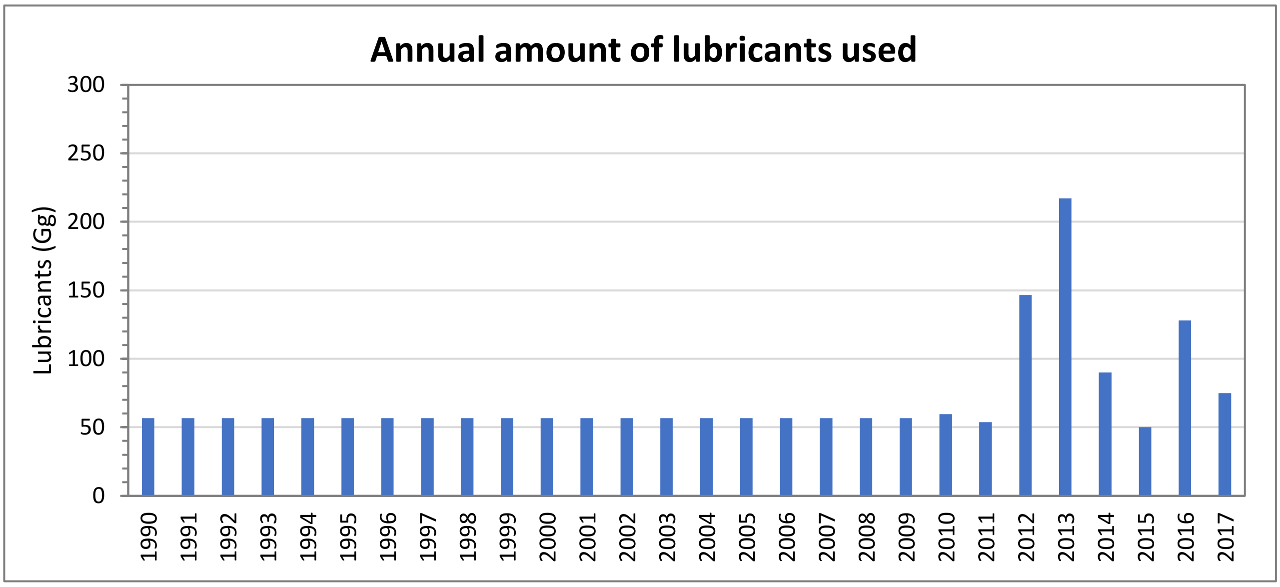


Figure 117 Annual amount of used lubricants: 1990-2017

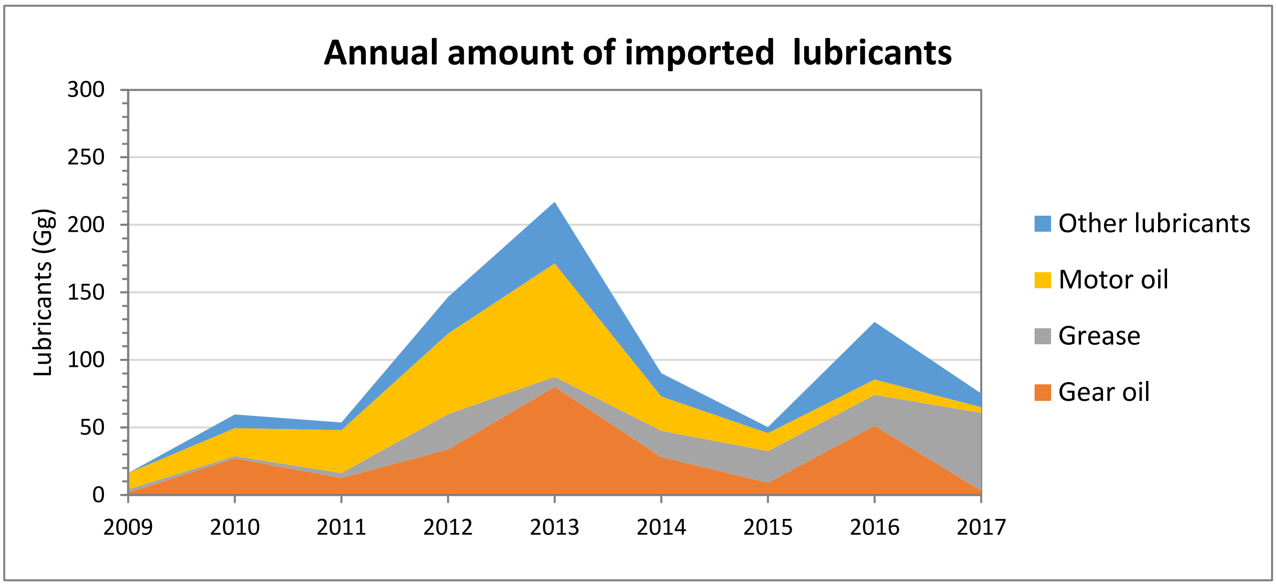


Figure 118 Annual amount of imported lubricants: gear oil, grease, motor oil and other lubricants: 2009-2017

Table 196 Activity data and CO_2 emissions from Lubricant Use (IPCC sub-category 2.D.1)

Years	Gear oil	Grease	Motor oil	Other lubricants		Lubricants (total)		
	Gg	Gg	Gg	Gg	Source	Gg	Source	TJ
1990	No detailed information available	No detailed information available	No detailed information available	No detailed information available		56.67	As of 2009	2,277.96
1991						56.67		2,277.96
1992						56.67		2,277.96
1993						56.67		2,277.96
1994						56.67		2,277.96
1995						56.67		2,277.96
1996						56.67		2,277.96
1997						56.67		2,277.96

Years	Gear oil	Grease	Motor oil	Other lubricants		Lubricants (total)		
	Gg	Gg	Gg	Gg	Source	Gg	Source	TJ
1998						56.67		2,277.96
1999						56.67		2,277.96
2000						56.67		2,277.96
2001						56.67		2,277.96
2002						56.67		2,277.96
2003						56.67		2,277.96
2004						56.67		2,277.96
2005						56.67		2,277.96
2006						56.67		2,277.96
2007						56.67		2,277.96
2008						56.67		2,277.96
2009	1.59	2.45	12.07	NO	NSIA Statistical Yearbook - Import / Export statistics Table 12-1 Table 12-3	56.67	Average of 2010 and 2011	2,277.96
2010	27.08	1.63	20.84	10.11		59.66	∑ gear oil, grease, motor oil, other lubricants	2,398.21
2011	12.51	3.67	31.71	5.78		53.67		2,157.72
2012	33.75	26.18	59.42	27.18		146.53		5,890.41
2013	80.06	7.29	84.15	45.61		217.11		8,727.84
2014	28.01	19.42	25.46	17.18		90.07		3,620.81
2015	9.07	23.45	13.33	4.32		50.17		2,016.69
2016	51.12	23.07	11.28	42.52		127.99		5,145.29
2017	3.12	57.79	4.18	9.96		75.04		3,016.53
Trend								
1990 – 2017	*NA*	*NA*	*NA*	*NA*		*32.4%*		*32.4%*
2005 - 2017	*NA*	*NA*	*NA*	*NA*		*32.4%*		*32.4%*
2016 - 2017	*-93.9%*	*150.5%*	*-63.0%*	*-76.6%*		*-41.4%*		*-41.4%*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic metres. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 2.D.1 *Lubricant Use*.

Table 197 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 2.D.1 Lubricant Use

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Lubricants	liquid	40.20	D	**2006 IPCC Guidelines, Vol. 2, Chap. 1, Table 1.2** Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
Note: D Default CS Country specific PS Plant specific				

4.4.1.2.3 Choice of emission factors

The emission factor is composed of a specific carbon content factor multiplied by the *Oxidized During Use* (ODU) factor. A further multiplication by 44/12 (the mass ratio of CO_2/C) yields the emission factor.

Tier 1:[124] Having only total consumption data for all lubricants, the weighted average *Oxidized During Use* (ODU) factor for lubricants as a whole is used as default value in the Tier 1 method. Assuming that 90% of the mass of lubricants is oil and 10% is grease, applying these weights to the ODU factors for oils and greases yields an overall (rounded) ODU factor of 0.2 (see table below).

Table 198 Carbon content and *Oxidized During Use* (ODU) factor applied in IPCC sub-category 2.D.1 Lubricant use.

Parameter	Carbon content of lubricants (default)	Fraction in total lubricant (default)	Oxidized During Use (ODU) factor (based on default composition of oil and grease)
Unit	kg C/GJ	%	fraction
IPCC Default for total lubricants	20.00	-	0.20
Lubricating oil (motor oil /industrial oils)	-	90	-
Grease	-	10	-
Source	Table 1.3, 2006 IPCC Guidelines, Vol. 2, Chap. 1, sub-chapter 1.4.2.1, page 1.21.	Table 5.2, 2006 IPCC Guidelines, Vol. 3, Chap. 5, sub-chapter 5.2.2.2, page 5.9.	

4.4.1.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 2.D.1 *Lubricant use* are presented in the following table.

Table 199 Uncertainty for IPCC sub-category 2.D.1 Lubricant use.

Uncertainty	CO_2	Reference
Activity data (AD)	20%	2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 5: Non-Energy Products from Fuels and Solvent Use, Sub-chapter 5.2.3.2, page 5.10
Emission factor (EF)	50%	
• *ODU factor*	*50%*	
• *Carbon content*	*3%*	
Combined Uncertainty (U)	54%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

[124] Source: 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 5: Non-Energy Products from Fuels and Solvent Use, Sub-chapter 5.2.2.2 Choice of emission factor (5.2 LUBRICANT USE). Page 5.9.

4.4.1.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed:

⇒ Checked of calculations by spreadsheets
  - consistent use of import and export statistics from NSIA,
  - documented sources,
  - use of units,
  - record keeping; use of write protection,
  - unique use of formulas; special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and international statistics (energy balance) of UN;

⇒ cross checks with other relevant sectors (Energy) are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ emission factors check – IEF;

⇒ time series consistency
  - plausibility checks of dips and jumps,
  - yearly public trend repeated values.

4.4.1.5 Source-specific recalculations of IPCC sub-category 2.D.1 Lubricant use

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 2.D.1 *Lubricant use*.

Table 200 Recalculations done since submission 2017 IPCC sub-category 2.D.1 Lubricant use.

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
2.D.1	No recalculation as this source is estimated the first time	-	-

4.4.1.6 Source-specific planned improvements for IPCC sub-category 2.D.1 Lubricant use

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.D.1	Investigation of import and export data of the entire time series	AD	Accuracy Transparency	High
2.D.1	Cross-check of national import and export statistics with international data (energy balance) of UN statistics of item non-energy use	AD	Accuracy Transparency Consistency	Medium
2.D.1	Investigation on specific details on the specific quantities of lubricants used as motor oils/industrial oils and as greases in order to apply TIER 2 methodology	AD	Accuracy Transparency	Medium
2.D.1	Investigation on country specific Net caloric value (NCV) for (specific types of) lubricants	AD	Accuracy Transparency	Medium

4.4.2 Paraffin Wax Use (IPCC subcategory 2.D.2)

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),
- etc.

Emissions from the use of waxes derive primarily when the waxes or derivatives of paraffins are combusted during use (e.g., candles), and when they are incinerated with or without heat recovery or in wastewater treatment (for surfactants). In the cases of incineration and wastewater treatment the emissions should be reported in the Energy or Waste Sectors, respectively.

4.4.2.1 Source category description

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.D.2	Paraffin Wax Use	✓	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The use of waxes s was responsible for less than 0.1% of GHG emissions in CO_{2eq} from industrial processes in 2017 and 1990 and for less than 0.1% of the total CO_2 emissions estimated in 2017 and 1990. It represented less than 0.2% of the total GHG emissions in 1990 and 217. The CO_2 emission are for the entire period 1990 – 2017 on a constant level of 0.02 Gg CO_2.

An overview of the *Lubricant Use* (IPCC sub-category 2.D.1) related CO_2 emissions is provided in the following figure and table.

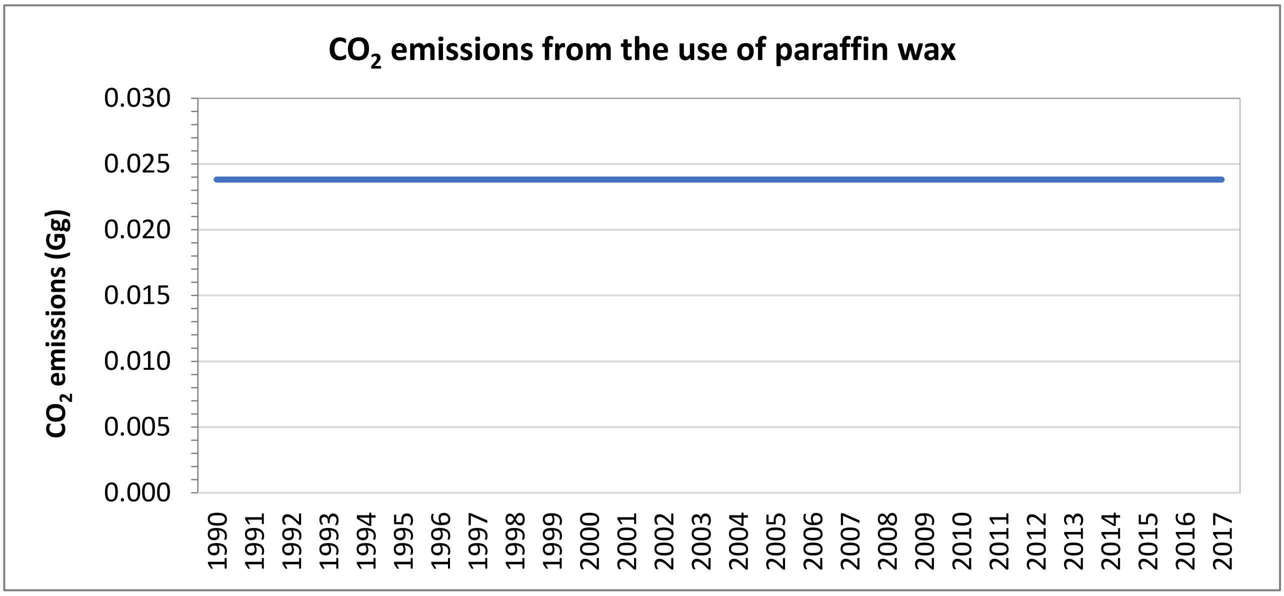


Figure 119 **CO_2 emissions from IPCC sub-category 2.D.2 Paraffin Wax Use 1990-2017**

Table 201 CO_2 emissions from Paraffin Wax Use (IPCC sub-category 2.D.2)

Years	**CO_2 emission**
	Gg
1990	0.0238
1991	0.0238
1992	0.0238
1993	0.0238
1994	0.0238
1995	0.0238
1996	0.0238
1997	0.0238
1998	0.0238
1999	0.0238
2000	0.0238
2001	0.0238
2002	0.0238
2003	0.0238
2004	0.0238
2005	0.0238
2006	0.0238
2007	0.0238
2008	0.0238
2009	0.0238
2010	0.0238
2011	0.0238
2012	0.0238
2013	0.0238
2014	0.0238
2015	0.0238
2016	0.0238
2017	0.0238
Trend	
1990 – 2017	*0%*
2005 - 2017	*0%*
2016 - 2017	*-0%*

4.4.2.2 Methodological issues

4.4.2.2.1 Choice of methods

The 2006 IPCC Guidelines Tier 1 approach[125] has been applied:

Equation 5.4: Tier 1 - Lubricants
(2006 IPCC GL, Vol. 3, Chap. 5.3.2.1)

$$CO_2\ emissions = PW \times CC_{wax} \times ODU_{wax} \times \frac{44}{12}$$

Where:

CO_2 Emissions	= emissions of CO_2 from wax (tonnes)
PW	= total paraffin wax consumption (TJ)
$CC_{paraffin}$	= (default) carbon content of paraffin wax (tonne C/TJ) (= kg C/GJ)
$ODU_{Lubricant}$	= ODU factor for paraffin wax (fraction)
44/12	= Conversion factor for mass ratio of CO_2/C

4.4.2.2.2 Choice of activity data

The data used in the inventory are based on import and export data provided for the years

- 2017 by National Statistics and Information Authority (NSIA)
- 1990 – 2016 As not data was available for the period, the value of 2017 was used for the entire period.

For the preparation of an entire time series two approaches were tested: consumption depending on population and constant consumption with reference year 2017. It was decided to use the constant value to the fact that paraffin wax products, e.g. candle, food processing, were used much more in the past then in the current year. In the following figures and table, the activity data are presented.

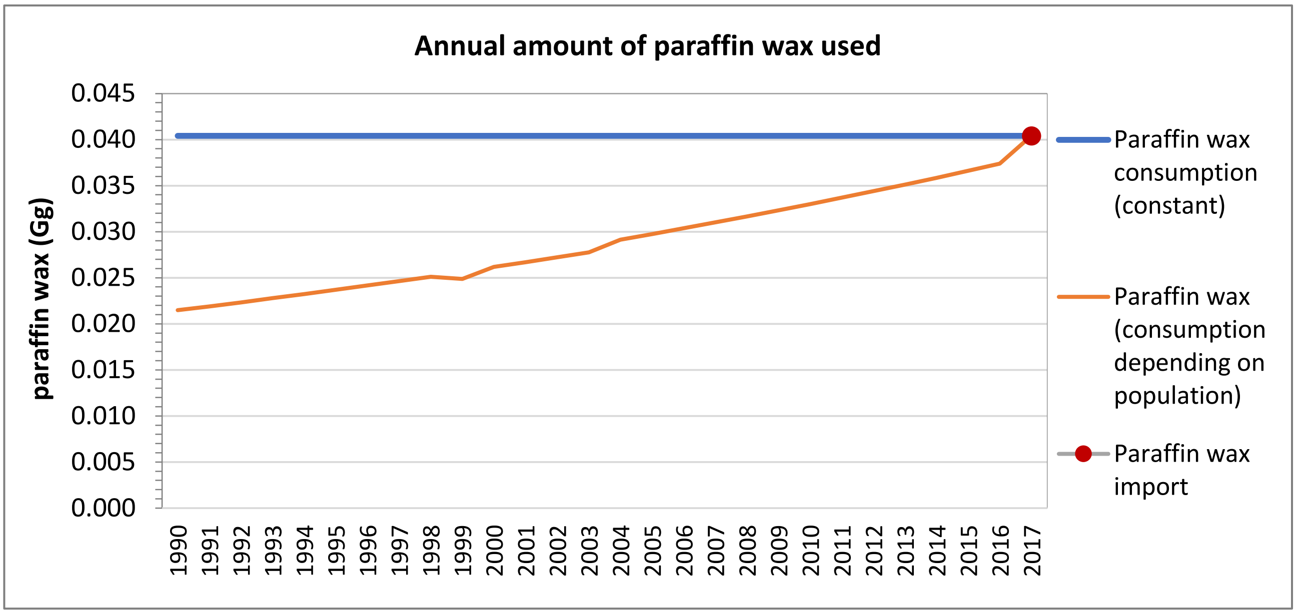


Figure 120 **Annual amount of Paraffin Wax: 1990-2017**

[125] Source: 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 5: Non-Energy Products from Fuels and Solvent Use, Sub-chapter 5.3.2.1 Choice of methods (5.3 Paraffin Wax use). Page 5.12.

Table 202 Activity data and CO_2 emissions from Paraffin Wax Use (IPCC sub-category 2.D.2)

Years	Paraffin wax		
	Gg	Source	TJ
1990	40.391		1.624
1991	40.391		1.624
1992	40.391		1.624
1993	40.391		1.624
1994	40.391		1.624
1995	40.391		1.624
1996	40.391		1.624
1997	40.391		1.624
1998	40.391		1.624
1999	40.391		1.624
2000	40.391		1.624
2001	40.391		1.624
2002	40.391		1.624
2003	40.391	As of 2017	1.624
2004	40.391		1.624
2005	40.391		1.624
2006	40.391		1.624
2007	40.391		1.624
2008	40.391		1.624
2009	40.391		1.624
2010	40.391		1.624
2011	40.391		1.624
2012	40.391		1.624
2013	40.391		1.624
2014	40.391		1.624
2015	40.391		1.624
2016	40.391		1.624
2017	40.391	NSIA Statistical Yearbook 2017/2018, Import / Export statistics, Table 12-1 & Table 12-3	1.624
Trend			
1990 – 2017	*0%*		*0%*
2005 - 2017	*0%*		*0%*
2016 - 2017	*0%*		*0%*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic metres. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 2.D.2 *Paraffin wax*.

Table 203 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 2.D.2 Paraffin Wax Use

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Paraffin wax	liquid	40.20	D	**2006 IPCC Guidelines, Vol. 2, Chap. 1, Table 1.2** Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
Note: D Default CS Country specific PS Plant specific				

4.4.2.2.3 Choice of emission factors

The emission factor is composed of a specific carbon content factor multiplied by the *Oxidized During Use* (ODU) factor. A further multiplication by 44/12 (the mass ratio of CO_2/C) yields the emission factor.

Tier 1:[126] It can be assumed that 20 percent of paraffin waxes are used in a manner leading to emissions, mainly through the burning of candles, leading to a default ODU factor of 0.2 (see table below).

Table 204 Carbon content and *Oxidized During Use* (ODU) factor applied in IPCC sub-category 2.D.2 Paraffin Wax Use.

Parameter	Carbon content of paraffin wax (default)	Oxidized During Use (ODU) factor (based on default composition of paraffin wax)
Unit	kg C/GJ	fraction
IPCC Default for paraffin wax	20.00	0.20
Source	Table 1.3, 2006 IPCC Guidelines, Vol. 2, Chap. 1, sub-chapter 1.4.2.1, page 1.21.	Table 5.2, 2006 IPCC Guidelines, Vol. 3, Chap. 5, sub-chapter 5.2.2.2, page 5.9.

4.4.2.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 2.D.2 *Paraffin Wax use* are presented in the following table.

[126] Source: 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 5: Non-Energy Products from Fuels and Solvent Use, Sub-chapter 5.3.2.2 Choice of emission factor (5.3 Paraffin Wax use). Page 5.12.

Table 205 Uncertainty for IPCC sub-category 2.D.2 Paraffin Wax Use.

Uncertainty	CO_2	Reference
Activity data (AD)	20%	2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 5: Non-Energy Products from Fuels and Solvent Use, Sub-chapter 5.2.3.2, page 5.10
Emission factor (EF)	50%	
• *ODU factor*	*50%*	
• *Carbon content*	*3%*	
Combined Uncertainty (U)	54%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

4.4.2.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed:

⇒ Checked of calculations by spreadsheets
- consistent use of import and export statistics from NSIA,
- documented sources,
- use of units,
- record keeping; use of write protection,
- unique use of formulas; special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and international statistics (energy balance) of UN;

⇒ cross checks with other relevant sectors (Energy) are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ emission factors check – IEF;

⇒ time series consistency
- plausibility checks of dips and jumps,
- yearly public trend repeated values.

4.4.2.5 Source-specific recalculations of IPCC sub-category 2.D.2 Paraffin Wax Use

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 2.D.1 *Paraffin Wax Use*.

Table 206 Recalculations done since submission 2017 IPCC sub-category 2.D.1 Lubricant use.

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
2.D.1	No recalculation as this source is estimated the first time	-	-

4.4.2.6 Source-specific planned improvements for IPCC sub-category 2.D.2 Paraffin Wax Use

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.D.1	Investigation of import and export data of the entire time series	AD	Accuracy Transparency	High
2.D.1	Cross-check of national import and export statistics with international data (energy balance) of UN statistics of item non-energy use	AD	Accuracy Transparency Consistency	Medium

4.4.3 Solvent Use (IPCC subcategory 2.D.3)

This chapter describes the methodology used for calculating air emissions from Solvent Use. Solvents are chemical compounds, which are used to dissolve substances as paint, glues, ink, rubber, plastic, pesticides or for cleaning purposes (degreasing). After application of these substances or other procedures of solvent use most of the solvents are released into air. Because solvents consist mainly of Non-Methane Volatile Organic Compounds (NMVOC). Besides the sources burning of fossil fuels, particularly for road transport and , energy production and distribution, solvent use is a major source for anthropogenic NMVOC emissions in Afghanistan. Once released into the atmosphere, NMVOCs react with reactive molecules (mainly HO-radicals) or high energetic light to finally form CO_2.

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.D.3	Solvent Use						
2.D.3.a	Domestic solvent use including fungicides	NE	-	NA	-	NA	-
2.D.3.b	Road paving with asphalt	NE	-	NA	-	NA	-
2.D.3.c	Asphalt roofing	NE	-	NA	-	NA	-
2.D.3.d	Coating applications	NE	-	NA	-	NA	-
2.D.3.e	Degreasing	NE	-	NA	-	NA	-
2.D.3.f	Dry cleaning	NE	-	NA	-	NA	-
2.D.3.g	Chemical products	NE	-	NA	-	NA	-
2.D.3.h	Printing	NE	-	NA	-	NA	-
2.D.3.i	Other solvent and product use	NE	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.D.3 *Solvent Use* is not estimated due to lack of resources and data. The priority was given to categories with higher contribution to national total GHG emissions of Afghanistan. The subcategory 2.D.3 *Solvent Use* has high contribution to national total NMVOC emissions but is only a small source of CO_2 and GHG respectively.

As described in the 2006 IPCC Guidelines, Vol. 1, Chap. 7 (7.2.1.5 Carbon emitted in gases other than CO_2) and Vol. 3, Chap. 5 (5.5 Solvent use) Most of the carbon emitted in the form of non-CO_2 species eventually oxidized to CO_2 in the atmosphere and this amount can be estimated from the emissions estimates of the non-CO_2 gases.is the default fossil carbon content fraction of NMVOC 60 percent by mass.

Equation Calculating CO_2 inputs to the atmosphere from emissions of carbon-containing compounds
From NMVOC: $Inputs_{CO2} = Emissions_{NMVOC} \bullet C \bullet 44/12$

Where

$Inputs_{CO2}$	= CO_2 emissions (Gg)
$Emissions_{NMVOC}$	= estimation of NMVOC (Gg)
C	= fraction carbon in NMVOC by mass (default = 0.6)
44/12	= conversion factor from C to CO_2

4.4.3.1 Source-specific planned improvements for IPCC sub-category 2.D.2 Solvent Use

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 207 Planned improvements for IPCC sub-category 2.D.3 Solvent use.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.D.3	Analysis of subcategories which are occurring in Afghanistan (see Table 208)	AD	Accuracy Transparency	High / Medium
2.D.3	Investigation of data on production, import and export of the solvents and solvent containing products for the recent years and for pillar years (e.g. 1990, 1995, 2000, 2005. 2010) (see Table 208)	AD	Accuracy Transparency	High / Medium

Table 208 Activity data needed for IPCC sub-category 2.D.3 Solvent use.

GHG source category	Subcategories	Activity data	
		TIER 1	TIER 2
2.D.3.a	**Domestic solvent use including fungicides**	kg/capita	
	• Agrochemical uses		kg solvent
	• Blowing agents		g/kg solvent
	• De-icing		g/kg solvent
	• Binder and release agents		g/kg solvent
	• Professional consumer cleaning		g/kg solvent
	• Industrial, professional and consumer coatings		g/kg solvent
	• Road and construction		g/kg solvent
	• Other consumer uses (households, aerosols, cosmetics)		g/kg solvent
	• Cosmetics and toiletries (general)		g/kg solvent
	• Cosmetics and toiletries (hair sprays)		g/kg solvent
	• Cosmetics and toiletries (toilet waters)		g/kg solvent
	• Cosmetics and toiletries (after shaves)		g/kg solvent
	• Cosmetics and toiletries (perfumes)		g/kg solvent
	• Cosmetics and toiletries (face care)		g/kg solvent

GHG source category	Subcategories	Activity data	
		TIER 1	TIER 2
	•		
	• Cosmetics and toiletries (personal deodorants & antiperspirants)		g/kg solvent
	• Cosmetics and toiletries (body care)		g/kg solvent
	• Household products (all)		g/kg solvent
	• Household products (soaps: liquid or paste)		g/kg solvent
	• Household products (polishes and creams for floors)		g/kg solvent
	• Household products (show polishes and creams)		g/kg solvent
	• Car care products (all)		g/kg solvent
	• Car care products (antifreeze agents in windscreen wiper systems)		g/kg solvent
	• Do it yourself (DIY)/buildings (all)		g/kg solvent
	• Do it yourself (DIY)/buildings (adhesives)		g/kg solvent
	• Do it yourself (DIY)/buildings (paint/varnish removers & solvents)		g/kg solvent
	• Do It Yourself (DIY)/buildings (sealants, filling agents)		g/kg solvent
	• Pesticides		g/kg solvent
2.D.3.b	Road paving with asphalt	g/Mg asphalt	g/Mg asphalt
2.D.3.c	Asphalt roofing (materials)	g/Mg shingle	g/Mg shingle
2.D.3.d	Coating applications	g/kg paint applied	
	• Coating applications		g/kg paint applied
	○ Decorative coating application		g/kg paint
	○ Industrial coating application		g/kg paint
	○ Other coating application		g/kg paint
	• Paint application		g/kg paint
	• Manufacture of automobiles		kg/car
	• Car repairing		g/kg paint
	• Construction and buildings		g/kg paint
	• Domestic use		g/kg paint
	• Coil coating		g/kg paint applied
	• Boat building		g/m2
	• Wood		g/kg paint applied
	• Other industrial paint application		g/kg paint
	• Other non-industrial paint application		g/kg paint
2.D.3.e	Degreasing	g/kg cleaning products	
	• Metal degreasing		g/kg cleaning products
	• Electronic components		kg/ton wafer
	• Other industrial cleaning		
2.D.3.f	Dry cleaning	g/kg textile treated	g/kg textiles cleaned
2.D.3.g	Chemical products	g/kg product	
	• Polyester processing		g/kg monomer used

GHG source category	Subcategories	Activity data	
		TIER 1	TIER 2
	•		
	• Polyvinylchloride processing		
	• Polyurethane foam processing		g/kg foam processed
	• Polystyrene foam processing		g/kg polystyrene
	• Rubber processing		g/kg rubber produced
	• Pharmaceutical products manufacturing		g/kg solvents used
	• Paints manufacturing		g/kg product
	• Inks manufacturing		g/kg product
	• Glues manufacturing		g/kg product
	• Asphalt blowing		g/Mg asphalt
	• Adhesive, magnetic tapes, films and photographs manufacturing		g/m2
	• Textile finishing		kg/pair of shoes
	• Leather tanning		g/kg raw hid
	• Other		g/kg tyres
2.D.3.h	Printing	g/kg ink	
	• Heat set offset		g/kg ink
	• Publication gravure		g/kg ink non diluted
	• Packaging, small flexography		g/kg ink ready to use
	• Packaging, large flexography		g/kg ink ready to use
	• Packaging, rotogravure		g/kg ink ready to use
2.D.3.i, 2.G	Other solvent and product use	kg/Mg product used	
	• Other use of solvents and related activities		g/kg solvent
	○ Glass wool induction		g/t glass wool
	○ Mineral wool induction		g/t mineral wool
	○ Fat, edible and non-edible oil extraction		g/kg seed
	○ Application of glues and adhesives		g/kg adhesives
	○ Preservation of wood		g/kg creosote or preservative
	○ Under seal treatment and conservation of vehicles		g/kg underseal agent
	○ Vehicles dewaxing		kg/car
	○ Other		Kg/ton deicing fluid used g/kg product
	• Use of HFC, N_2O, NH3, PFC & SF6		
	○ Other		
	• Other product use		g/t product
	○ Use of fireworks		g/t product
	○ Use of tobacco		kg/Mg tobacco
	○ Use of shoes		g/pair
	○ Other		g/t product

4.4.4 Other (IPCC subcategory 2.D.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.D.4	Other	NE	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC subcategory 2.D.4 *Other* does not exist in Afghanistan.

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4.5 Electronics Industry (IPCC category 2.E)

This section describes GHG emissions resulting from gases used in manufacturing different types of electronic devices, the process used (or more roughly, process type (e.g., CVD or etch)), the brand of process tool used, and the implementation of emission reduction technology.

All these activities are not existing in Afghanistan.

4.5.1 Integrated Circuit or Semiconductor (IPCC subcategory 2.E.1)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.1	Integrated Circuit or Semiconductor	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.1	Integrated Circuit or Semiconductor	NO	-	NO	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.E.1 *Integrated Circuit or Semiconductor* does not exist in Afghanistan.

4.5.2 TFT Flat Panel Display (IPCC subcategory 2.E.2)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.3	TFT Flat Panel Display	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.3	TFT Flat Panel Display	NO	-	NO	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.C.2 *TFT Flat Panel Display* does not exist in Afghanistan.

4.5.3 Photovoltaics (IPCC subcategory 2.E.3)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.3	Photovoltaics	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.3	Photovoltaics	NO	-	NO	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.C.3 *Photovoltaics* does not exist in Afghanistan.

4.5.4 Heat Transfer Fluid (IPCC subcategory 2.E.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.4	Heat Transfer Fluid	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.4	Heat Transfer Fluid	NO	-	NO	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.E.4 *Heat Transfer Fluid* does not exist in Afghanistan.

4.5.5 Other (IPCC subcategory 2.F.5)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.5	Other	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.5	Other	NO	-	NO	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.F.5 *Other* does not exist in Afghanistan.

4.6 Product Uses as Substitutes for Ozone Depleting Substances (IPCC category 2.F)

The IPCC category 2.F *Product Uses as Substitutes for Ozone Depleting Substances* (ODS) comprises

- HFC, PFC and SF6 emissions from Refrigeration and Air Conditioning units (2.F.1),
- HFC, PFC and SF6 emissions from Foam Blowing Agents (2.F.2),
- HFC, PFC and SF6 emissions from Fire Protection applications and products (2.F.3),
- HFC, PFC and SF6 emissions from Aerosols (2.F.4),
- HFC, PFC and SF6 emissions from Solvents (2.F.5),
- HFC, PFC and SF6 emissions from other applications (2.F.6).

All sub-categories are existing in Afghanistan but are currently not estimated due to lack of resources and (sufficient) data.

4.6.1 General remarks related to F-gases

HFC and PFC as Substitutes for ODS – so called F-gases

(A) refrigeration and air-conditioning are by far the main application
HFC and partially PFC are used in fire suppression, aerosols, solvents, foam etc.
⇒ see Table 209

(B) F-gases occur as pure substances or as blends
⇒ see Table 210and Table 211

(C) emissions arise from:
- production (by-product, fugitive)
  - Manufacturing or assembly emissions
    - Leaks at filling
  - Intended release during use of products
- during use (intended, leakage)
  - Prompt emissions (< 2 years after being charged into a product)
    - as aerosols or propellants
  - Leaks during use / operation of products
  - Container losses
- Release at the end of life of products / decommissioning

(D) F-gases are traded products (no formation in processes)
⇒ see Figure 121 and related discussion on data

(E) development of long-lived banks makes the calculation difficult
⇒ see Figure 122

Table 209 Main application areas for HFCs and PFCs as ODS substitutes.

Chemical	Refrigeration and Air Conditioning	Fire Suppression and Explosion Protection	Aerosols		Solvent Cleaning	Foam Blowing	Other Applications
			Propellants	Solvents			
HFC-23	X	X					
HFC-32	X						
HFC-125	X	X					
HFC-134a	X	X	X			X	X
HFC-143a	X						
HFC-152a	X		X			X	
HFC-227ea	X	X	X			X	X
HFC-236fa	X	X					
HFC-245fa				X		X	
HFC-365mfc				X	X	X	
HFC-43-10mee				X	X		
PFC-14 (CF_4)		X					
PFC-116 (C_2F_6)							X
PFC-218 (C_3F_8)							
PFC-31-10 (C_4F_{10})		X					
PFC-51-14 (C_6F_{14})					X		

Remarks Main application areas for HFCs and PFCs as ODS substitutes: Several applications use HFCs and PFCs as components of blends. The other components of these blends are sometimes ODSs and/or non-greenhouse gases. Several HFCs, PFCs and blends are sold under various trade names; only generic designations are used in this chapter.

Other applications include sterilization equipment, tobacco expansion applications, plasma etching of electronic chips (PFC-116) and as solvents in the manufacture of adhesive coatings and inks.

PFC-14 (chemically CF4) is used as a minor component of a proprietary blend. Its main use is for semiconductor etching.

PFC-51-14 is an inert material, which has little or nil ability to dissolve soils. It can be used as a carrier for other solvents or to dissolve and deposit disk drive lubricants. PFCs are also used to test that sealed components are hermetically sealed.

Source: 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. Table 7.1. Page 7.1.

Table 210 ASHRE name and chemical formula of HFCs, PFCs, CFCs and other refrigerants

PFC (fully fluorinated hydrocarbons)		
ASHRAE name	**chemical formula**	**name**
R 14	CF4	perfluormethan
R 116	C2F6	perfluorethan
R 218	C3F8	perfluorpropan
RC 318	C4F8	perfluorcyclobutane
R 3110	C4F10	perfluorbutan
HFCs (partly fluorinated hydrocarbons)		
ASHRAE name	**Chemical formula**	**name**
R 23	CHF3	trifluormethan
R 32	CH2F2	difluormethan
R 41	CH3F	fluormethan
R 43 10mee	C5H2F10	dekaflouropentan
R 125	CHF2CF3	pentafluoroethan
R 134a	CF3CHF	tetrafluorethan
R 143a	CF3CH3	trifluorethan
R 152a	CHF2CH3	difluorethan
R 227ea	CF3CFHCF3	heptafluoropropan
R 236fa	C3H2F6	hexafluoropropan
R 245ea	CF3CH2CF2H	pentafluoropropan

ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers

CFCs (chlorofluorocarbons)		
ASHRAE name	**Chemical formula**	
R 11	CCl3F	trichlorflourmethan
R 12	CCl2F2	dichlordiflourmethan
R 13	CClF3	chlortriflourmethan
R 22	CHClF2	chlordifluormethan
R 113	CClF2CCl2F	trichlortriflourethan
R 114	CClF2CClF2	dichlortetraflourethan
R 115	CClF2CF3	chlorpentaflourethan
R 123	CHCl2CF3	dichlortriflourethan
R 124	CHClFCF3	chlortriflourethan
R 141b	CCl2FCH3	dichlorflourethan
R 142b	CClF2CH3	chlordiflourethan
Other refrigerants		
ASHRAE name	**Chemical formula**	**name**
R 12B1	CBrClF2	halon 1221
R 13B1	CBrF3	halon 1301
R 50	CH_4	methane
R 290	C3H8	propane
RC 318	C4F8	perfluorocyclobutane
R 600a	CH3CH(CH3)2	iso-butane
R 717	NH3	ammonia
R 718	H2O	water
R1270		propene

Table 211 ASHRAE name and chemical formula of HFCs, PFCs, CFCs and other refrigerants

ASHRAE name	Components				Composition [%]			
R 401A	R22	R152a	R124		53	13	34	
R 401B	R22	R152a	R124		61	11	28	
R 401C	R22	R152a	R124		33	15	52	
R 402A	R22	R125	R290		38	60	2	
R 402B	R22	R125	R290		60	38	2	
R 403B	R22	R218	R290		56	39	5	
R 404A	R125	R143a	R134a		44	52	4	
R 405A	R22	R152a	R142b	RC318	45	7	5.5	42.5
R 406A	R22	R600a	R142b		55	4	41	
R 407A	R32	R125	R134a		20	40	40	
R 407B	R32	R125	R134a		10	70	20	
R 407C	R32	R125	R134a		23	25	52	
R 407D	R32	R125	R134a		15	15	70	
R 407E	R32	R125	R134a		25	15	60	
R 408A	R125	R143a	R22		7	46	47	
R 409A	R22	R124	R142b		60	25	15	

ASHRAE name	Components				Composition [%]			
R 409B	R22	R124	R142b		65	25	10	
R 410A	R32	R125			50	50		
R 411A	R1270	R22	R152a			87.5	11	
R 411B	R1270	R22	R152a		3	94	3	
R 411C	R1270	R22	R152a		3	95.5	1.5	
R 412A	R22	R 218	R142b		70	5	25	
R 413A	R 218	R134a	R600		9	88	3	
R 414A	R22	R124	R600a	R142b	51	28.5	4	16.5
R 414B	R22	R124	R600a	R142b	50	39	1.5	9.5
R 416A	R134a	R124	R600		59	39.5	1.5	
R 417A	R125	R134a	R600		46.6	50		
R 422A	R125	R134a	R600a		85.1	11.5	3.4	
R 422D	R125	R134a	R600a		65.1	31.5	3.4	
R 437A	R125	R134a	R600	R601	19.5	78.5	1.4	0.6
R 500	R12	R152a						
R 502	R22	R115			48.8	51.2		
R 503	R23	R13			40	60		
R 507	R125	R143a			50	50		
R 508A	R23	R116			39	61		
R 508B	R23	R116			46	54		
R 509A	R22	R218			44	56		

Discussion on import data

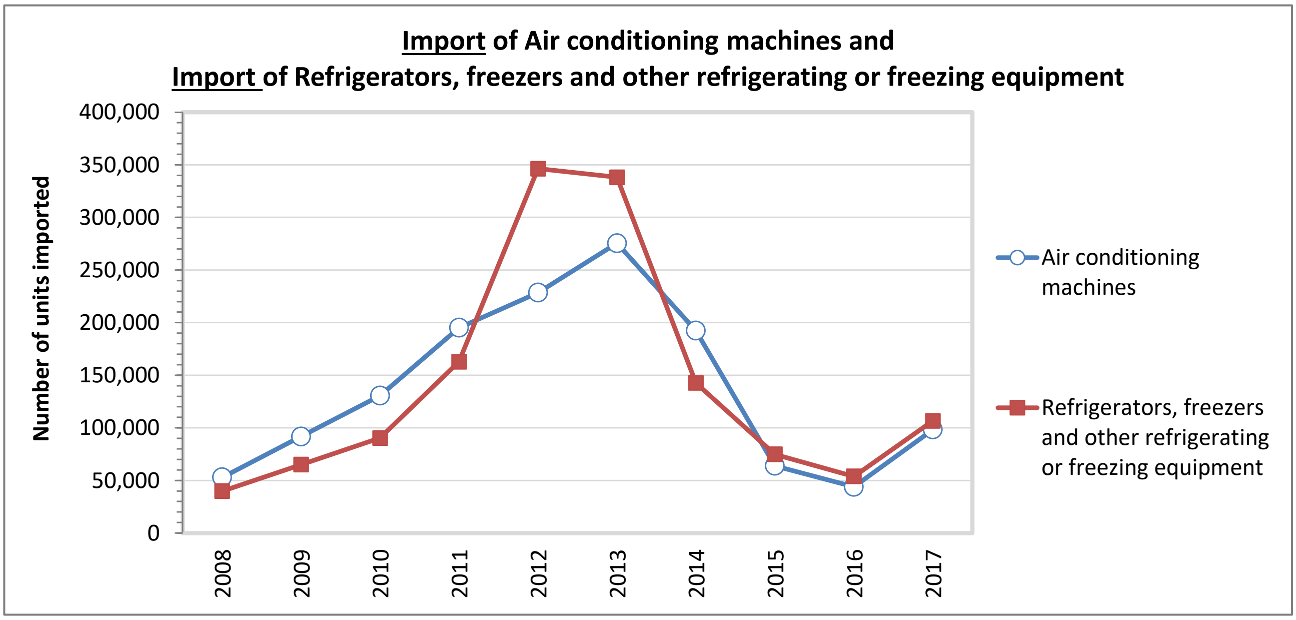


Figure 121 Data of the import of (1) air conditioning machines and (2) refrigerators, freezers and other refrigerating or freezing equipment

Source: NSIA (different years): Statistical Yearbook - Import / export statistics (Table 12-3).

In the following figure are presented data of the import of (1) air conditioning machines and (2) refrigerators, freezers and other refrigerating or freezing equipment which were taken from the import / export statistics of the Statistical Yearbook published by NSIA. For estimation of GHG emissions from the use of these units, machines and equipment, more detailed data regarding domestic, commercial or industrial use or stand-alone unit, condensing unit or centralized system are required. See here Table 213.

Therefore, it was decided not to estimate GHG emissions. For the next inventory cycle an in-depth analysis of the available data has to be conducted and a close cooperation of all stakeholders who are importing, dealing, selling, maintaining and disposing the HFC, PFC and SF6 containing products, units, equipment and machines.

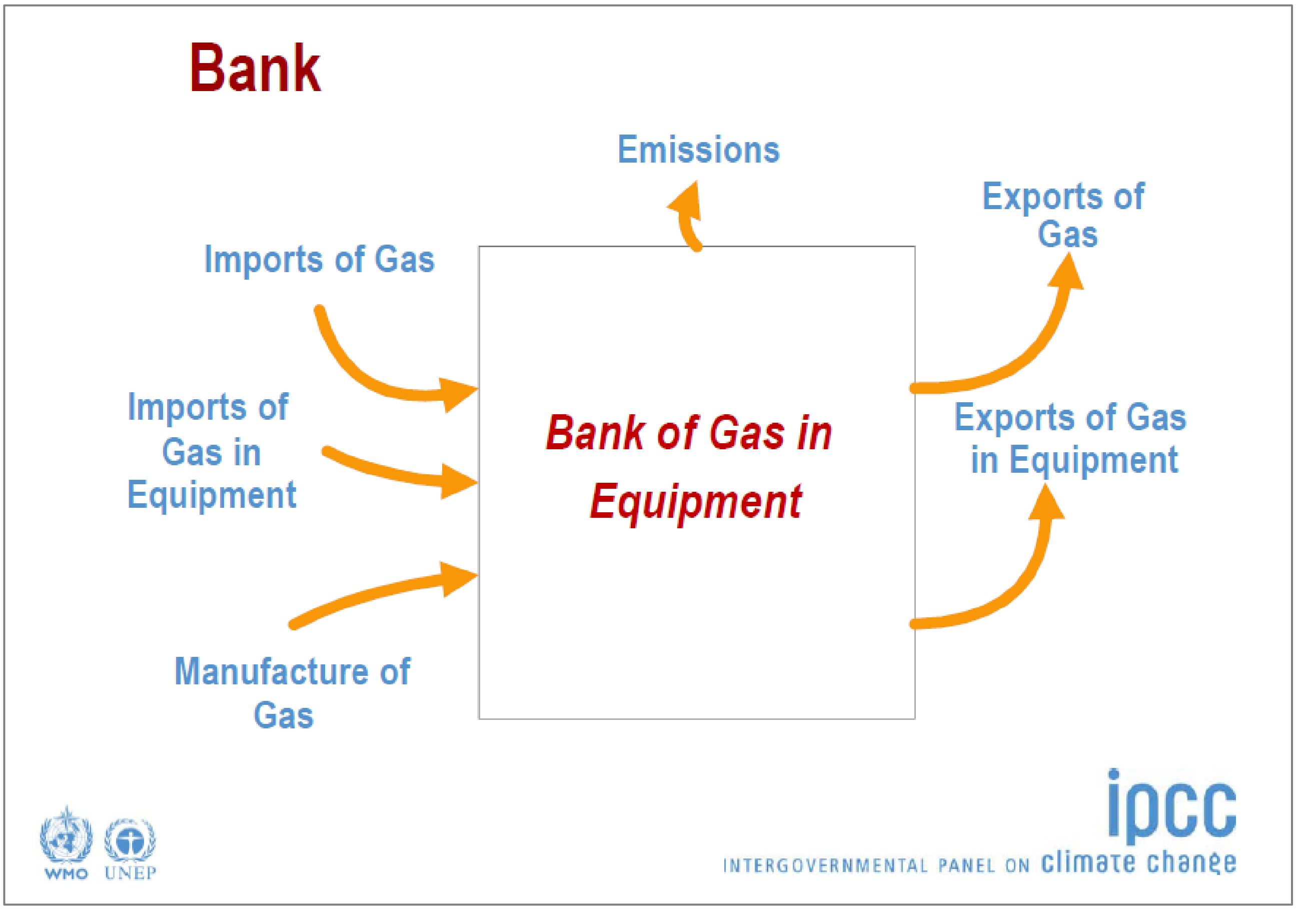


Figure 122 **Bank of gas equipment**

Source: IPCC TFI TSU (2016): Industrial Processes and Product Use (IPPU). Africa Regional Workshop on the Building of Sustainable National Greenhouse Gas Inventory Management Systems, and the Use of the 2006 IPCC Guidelines. SHERMANAU, P. 14-18 March 2016, Lesotho, Maseru.

4.6.2 Electrical Equipment (IPCC subcategory 2.F.1)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.1	Refrigeration and Air Conditioning						
2.F.1.a	Refrigeration and Stationary Air Conditioning	NA	-	NA	-	NA	-
2.F.1.b	Mobile Air Conditioning	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.1	Refrigeration and Air Conditioning								
2.F.1.a	Refrigeration and Stationary Air Conditioning	NE	-	NE	-	NE	-	NE	-
2.F.1.b	Mobile Air Conditioning	NE	-	NE	-	NE	-	NE	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.F.1 *Refrigeration and Air Conditioning* is not estimated but the estimation of HFC, PFC and SF6 emissions from use, maintaining and disposal of refrigerators, freezers and air-condition machines containing HFC, PFC and SF6 is planned for next inventory cycle.

4.6.2.1 Source-specific planned improvements for IPCC sub-category 2.F.1 Refrigeration and Air Conditioning

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 212 Planned improvements for IPCC sub-category 2.F.1 Refrigeration and Air Conditioning.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.1	In-depth analysis of (a) data on historic and current equipment (b) production, import & export of commodities of • HS code 8415 'Air-condition' • HS code 8418 'Refrigerator and freezer'	AD	Accuracy Transparency Completeness Comparability	High
2.F.1	In-depth analysis of (a) data on historic and current equipment (b) production, import & export of commodities of • Containing fluids / gases • Container size • Lifetime	AD	Accuracy Transparency Completeness Comparability	High

GHG source & sink category	Planned improvement	Type of improvement		Priority
	• usage pattern • maintenance • disposal			
2.F.1	Analysis of mobile air-conditioning units/equipment	AD	Accuracy Transparency Completeness Comparability	High
2.F.1	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.5 REFRIGERATION AND AIR CONDITIONING) Page 7.43.	AD	Accuracy Transparency Completeness Comparability	High

Table 213 Relevant commodity relevant to IPCC sub-category 2.F.1 Refrigeration and Air Conditioning

Commodity	HS-code	Name of Commodity
Air-condition	**8415**	**Air conditioning machines; comprising a motor driven fan and elements for changing the temperature and humidity, including those machines in which the humidity cannot be separately regulated**
	841510	Air conditioning machines; comprising a motor-driven fan and elements for changing the temperature and humidity, of a kind designed to be fixed to a window, wall, ceiling or floor, self-contained or "split-system"
	841520	Air conditioning machines; comprising a motor driven fan and elements for changing the temperature and humidity, of a kind used for persons, in motor vehicles
	841581	Air conditioning machines; containing a motor driven fan, other than window or wall types, incorporating a refrigerating unit and a valve for reversal of the cooling/heat cycle (reversible heat pumps)
	841582	Air conditioning machines; containing a motor driven fan, other than window or wall types, incorporating a refrigerating unit
	841583	Air conditioning machines; containing a motor driven fan, other than window or wall types, not incorporating a refrigerating unit
	841590	Air conditioning machines; with motor driven fan and elements for temperature control, parts thereof
Refrigerators	**8418**	**Refrigerators, freezers and other refrigerating or freezing equipment, electric or other; heat pumps other than air conditioning machines of heading no. 8415**
	841810	Refrigerators and freezers; combined refrigerator-freezers, fitted with separate external doors, electric or other
	841821	Refrigerators; for household use, compression-type, electric or other
	841829	Refrigerators; household, electric or not, other than compression-type
	841830	Freezers; of the chest type, not exceeding 800l capacity
	841840	Freezers; of the upright type, not exceeding 900l capacity
	841850	Furniture incorporating refrigerating or freezing equipment; for storage and display, n.e.c. in item no. 8418.1, 8418.2, 8418.3 or 8418.4 (chests, cabinets, display counters, showcases and the like)
	841861	Heat pumps; other than air conditioning machines of heading no. 8415

Commodity	HS-code	Name of Commodity
	841869	Refrigerating or freezing equipment; n.e.c. in heading no. 8418
	841891	Refrigerating or freezing equipment; parts, furniture designed to receive refrigerating or freezing equipment
	841899	Refrigerating or freezing equipment; parts thereof, other than furniture

4.6.3 Foam Blowing Agents (IPCC subcategory 2.F.2)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.2	Foam Blowing Agents	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.2	Foam Blowing Agents	NE	-	NE	-	NE	-	NE	-

A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment

The IPCC subcategory 2.F.2 *Foam Blowing Agents* is not estimated but the estimation of GHG emissions from Foam Blowing Agents is planned for next inventory cycle.

4.6.3.1 Source-specific planned improvements for IPCC sub-category 2.F.2 Foam Blowing Agents

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 214 Planned improvements for IPCC sub-category 2.F.2 Foam Blowing Agents.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.2	Analysis of Foam Blowing Agents, e.g. • the amount of chemical used in foam manufacturing in a country and not subsequently exported • the amount of chemical contained in foam imported	AD	Accuracy Transparency Completeness Comparability	High
2.F.2	Investigation on applications • Polyurethane – Integral Skin / Polyurethane – Continuous Panel / Discontinuous Panel / Appliance / Injected / etc. • One Component Foam (OCF) • Extruded Polystyrene (XPS) • Phenolic – Discontinuous Block / Discontinuous Laminate	AD	Accuracy Transparency Completeness Comparability	High

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.2	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.4 FOAM BLOWING AGENTS) Page 7.32.	AD	Accuracy Transparency Completeness Comparability	High

4.6.4 Fire Protection (IPCC subcategory 2.F.3)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.3	Fire Protection	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.3	Fire Protection	NE	-	NE	-	NE	-	NE	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.F.3 *Fire Protection* is not estimated but the estimation of GHG emissions from the fire protection products and fire protection equipment is planned for next inventory cycle.

4.6.4.1 Source-specific planned improvements for IPCC sub-category 2.F.3 Fire Protection

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 215 Planned improvements for IPCC sub-category 2.F.3 Fire Protection.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.3	Investigation of import and use of fire protection products and fire protection equipment	AD	Accuracy Transparency Completeness	High
2.F.3	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.6 FIRE PROTECTION) Page 7.61.	AD	Accuracy Transparency Completeness Comparability	High

4.6.5 Aerosols (IPCC subcategory 2.F.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.4	Aerosols	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.4	Aerosols	NE	-	NE	-	NE	-	NE	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.F.4 *Aerosols* is not estimated but the estimation of GHG emissions from the use of aerosols containing HFC and/or PFC is planned for next inventory cycle.

4.6.5.1 Source-specific planned improvements for IPCC sub-category 2.F.4 Aerosols

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 216 Planned improvements for IPCC sub-category 2.F.4 Aerosols.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.4	Investigation of • Domestic aerosol production • Imported aerosol production	AD	Accuracy Transparency Completeness	High
2.F.4	Investigation of the use and consumption (by chemical composition) of products containing HFC and/or PFC for cleaning: (i) Metered Dose Inhalers (MDIs); (ii) Personal Care Products (e.g., hair care, deodorant, shaving cream); (iii) Household Products (e.g., air-fresheners, oven and fabric cleaners); (iv) Industrial Products (e.g., special cleaning sprays such as those for operating electrical contact, lubricants, pipe-freezers); (v) Other General Products (e.g., silly string, tyre inflators, klaxons).	AD	Accuracy Transparency Completeness	High
2.F.4	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.3 AEROSOLS (PROPELLANTS AND SOLVENTS)) Page 7.28.	AD	Accuracy Transparency Completeness Comparability	High

4.6.6 Solvents (IPCC subcategory 2.F.5)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.5	Solvents	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.5	Solvents	NE	-	NE	-	NE	-	NE	-

A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment

The IPCC subcategory 2.F.5 *Solvents* is not estimated but the estimation of GHG emissions from the use of solvents containing HFC and/or PFC for cleaning ((i) Precision Cleaning, (ii) Electronics Cleaning, (iii) Metal Cleaning, (iv) Deposition applications) is planned for next inventory cycle.

4.6.6.1 Source-specific planned improvements for IPCC sub-category 2.F.5 Solvents

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 217 Planned improvements for IPCC sub-category 2.F.5 Solvents.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.5	Investigation of the use and consumption (by chemical composition) of solvents containing HFC and/or PFC products for (i) Precision Cleaning, (ii) Electronics Cleaning, (iii) Metal Cleaning, (iv) Deposition applications).	AD	Accuracy Transparency Completeness	High
2.F.5	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.3 AEROSOLS (PROPELLANTS AND SOLVENTS) Page 7.28.	AD	Accuracy Transparency Completeness Comparability	High

4.6.7 Other Application (IPCC subcategory 2.F.6)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.6	Other Application	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.6	Other Application	NE	-	NE	-	NE	-	NE	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.F.6 *Other Application* is not estimated but the estimation of GHG emissions from the use of various products is planned for next inventory cycle.

4.6.7.1 Source-specific planned improvements for IPCC sub-category 2.F.6 Other Application

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 218 Planned improvements for IPCC sub-category 2.F.6 Other Application .

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.6	Investigation of the use and consumption (by chemical composition) of various products containing HFC and/or PFC	AD	Accuracy Transparency Completeness	High
2.F.6	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.7 OTHER APPLICATIONS) Page 7.66.	AD	Accuracy Transparency Completeness Comparability	High

4.7 Other Product Manufacture and Use (IPCC category 2.G)

The IPCC category 2.G *Other Product Manufacture and Use* comprises

- PFC and SF6 emissions from Electrical Equipment (2.G.1),
- PFC and SF6 emissions from Other Product Uses (2.G.2),
- N_2O emissions from Product Uses (2.G.3).

Whereas the sub-category 2.G.1 does not exist in Afghanistan, the subcategories 2.G.2 and 2.G.3 are not estimated due to lack of resources and data.

4.7.1 Electrical Equipment (IPCC subcategory 2.G.1)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.1	Electrical Equipment						
2.G.1.a	Manufacture of Electrical Equipment	NA	-	NA	-	NA	-
2.G.1.b	Use of Electrical Equipment	NA	-	NA	-	NA	-
2.G.1.c	Disposal of Electrical Equipment	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.1	Electrical Equipment								
2.G.1.a	Manufacture of Electrical Equipment	NO	-	NO	-	NO	-	NO	-
2.G.1.b	Use of Electrical Equipment	NO	-	NO	-	NO	-	NO	-
2.G.1.c	Disposal of Electrical Equipment	NO	-	NO	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.G.1 *Electrical Equipment* does not exist in Afghanistan.

4.7.2 SF6 and PFCs from Other Product Uses (IPCC subcategory 2.G.2)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.2	SF6 and PFCs from Other Product Uses						
2.G.2.a	Military	NA	-	NA	-	NA	-

	Applications						
2.G.2.b	Accelerators						
2.G.2.b.i	University and Research Particle Accelerators	NA	-	NA	-	NA	-
2.G.2.b.ii	Industrial and Medical Particle Accelerators	NA	-	NA	-	NA	-
2.G.2.c	Other	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.2	SF6 and PFCs from Other Product Uses								
2.G.2.a	Military Applications	NO	-	NO	-	NE	-	NO	-
2.G.2.b	Accelerators								
2.G.2.b.i	University and Research Particle Accelerators	NO	-	NO	-	NO	-	NO	-
2.G.2.b.ii	Industrial and Medical Particle Accelerators	NO	-	NO	-	NO	-	NO	-
2.G.2.c	Other	NO	-	NO	-	NE	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.G.2 *SF6 and PFCs from Other Product Uses* is not estimated but the estimation of SF6 and PFCs emissions from use of other products containing SF6 and PFCs is planned for next inventory cycle.

4.7.2.1 Source-specific planned improvements for IPCC sub-category 2.G.2 SF6 & PFCs from ODU

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 219 Planned improvements for IPCC sub-category 2.G.2 SF6 and PFCs from Other Product Use.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.G.2	Analysis of production, import and export of 'other products' containing SF6 and PFCs, e.g. • SF6 and PFCs used in military applications • SF6 used in sound-proof windows • SF6 used in shoes	AD	Accuracy Transparency Completeness Comparability	High
2.G.2	Estimation of SF6 and PFCs emissions from use of 'other products' containing SF6 and PFCs according to 2006 IPCC Guidelines, Vol. 3, Chapter 8: Other Product Manufacture	AD	Accuracy Transparency	High

GHG source & sink category	Planned improvement	Type of improvement		Priority
	and Use (8.3 USE OF SF6 AND PFCs IN OTHER PRODUCTS)		Completeness Comparability	

4.7.3 N_2O from Product Uses (IPCC subcategory 2.G.3)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.3	N_2O from Product Uses						
2.G.3.a	Medical Applications	NA	-	NA	-	NE	-
2.G.3.b	Propellant for pressure and aerosol products	NA	-	NA	-	NE	-
2.G.3.c	Other	NA	-	NA	-	NE	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.3	N_2O from Product Uses								
2.G.3.a	Medical Applications	NA	-	NA	-	NA	-	NA	-
2.G.3.b	Propellant for pressure and aerosol products	NA	-	NA	-	NA	-	NA	-
2.G.3.c	Other	NA	-	NA	-	NA	-	NA	-

A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment

The IPCC subcategory 2.G.3 *N_2O from Product Uses* is not estimated but the estimation of N_2O emissions from the use of products containing N_2O is planned for next inventory cycle.

4.7.3.1 Source-specific planned improvements for IPCC sub-category 2.G.3 N_2O from Product Uses

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 220 Planned improvements for IPCC sub-category 2.G.3 N_2O from Product Use.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.G.3	Estimation of N_2O emissions from the use of products containing N_2O applying Tier 1 of 2006 IPCC Guidelines, Vol. 3, Chapter 8: Other Product Manufacture and Use (N_2O FROM PRODUCT USES)	AD	Accuracy Transparency Completeness Comparability	High

4.7.4 Other (IPCC subcategory 2.G.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.4	Other	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.4	Other	NO	-	NO	-	NO	-	NO	-

A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment

The IPCC subcategory 2.G.4 *Other* does not exist in Afghanistan.

4.8 Other (IPCC category 2.H)

The IPCC category 2.H comprises activities withing Pulp and paper as well as Food and drink industry, where GHG emissions are arising. These industries emit only process related GHGs of biogenic origin and those have not been accounted for according to the guidelines.

4.8.1 Pulp and Paper Industry (IPCC subcategory 2.H.1)

IPCC code	Description	Fossil CO_2		Biogenic CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.H.1	Pulp and Paper Industry	NA	-	NE	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.H.1 *Pulp and Paper Industry* exists in Afghanistan. Pulp and paper industry emit only process related GHGs of biogenic origin and those have not been accounted for according to the 2006 IPCC guidelines. Relevant GHG emission from fuel combustion activities in *Pulp and Paper Industry* are reported in IPCC category 1.A.2 *Manufacturing Industries and Construction - Pulp, Paper and Print* (IPCC sub-category 1.A.2.d).

4.8.2 Food and Beverages Industry (IPCC subcategory 2.H.2)

IPCC code	Description	Fossil CO_2		Biogenic CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.H.2	Food and Beverages Industry	NA	-	NE	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.D.2 *Food and Beverages Industry* does not exist in Afghanistan. Food and Beverages Industry emit only process related GHGs of biogenic origin and those have not been accounted for according to the 2006 IPCC guidelines. Relevant GHG emission from fuel combustion activities in *Food and Beverages Industry* are reported in IPCC category 1.A.2 *Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco* (IPCC subcategory 1.A.2.e).

4.8.3 Other (IPCC subcategory 2.H.3)

IPCC code	Description	Fossil CO_2		Biogenic CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.H.3	Other (please specify)	NA	-	NE	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year); TA – Trend Assessment									

The IPCC subcategory 2.H.3 *Other* does not exist in Afghanistan.

5 AFOLU - Agriculture (IPCC sector 3)

This chapter includes information on, and description of methodologies used for estimating GHG emissions as well as references to activity data and emission factors reported under IPCC Sector 3 Agriculture for the period 1990 to 2017.

GHG emissions from this sector comprise emissions from the following categories:

IPCC Code	Description	CO_2	CH_4	N_2O
3.A.1	Enteric Fermentation	NA	✓	NA
3.B.2	Manure Management	NA	✓	✓
3.C	Rice Cultivation	NA	✓	NA
3.D.a	Direct N_2O emissions from managed soils	NA	NA	✓
3.D.b	Indirect N_2O Emissions from managed soils	NA	NA	✓
3.E	Prescribed burning of savannas	NA	NO	NO
3.F	Field burning of agricultural residues	NA	✓	✓
3.G	Liming	NO	NA	NA
3.H	Urea application	✓	NA	NA
3.I	Other carbon-containing fertilizers	NO	NA	NA
3.J	Other (please specify)	NO	NA	NA
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential				

Emissions from the Agriculture Sector are of important source of GHGs in Afghanistan:

- in 1990 about 72.7% of the total national GHG emissions and 1% of total CO_2 emissions arose from the sector Agriculture, whereas N_2O and CH_4 emissions make up about 93.7% and 88.4%, respectively.
- in 2005 about 71.4% of the total national GHG emissions and 0.4% of total CO_2 emissions arose from the sector Agriculture, whereas N_2O and CH_4 emissions make up about 95.1% and 88.6%, respectively.
- in 2017 about 46.2% of the total national GHG emissions and 0.3% of total CO_2 emissions arose from the sector Agriculture, whereas N_2O and CH_4 emissions make up about 92.0% and 87.6%, respectively.

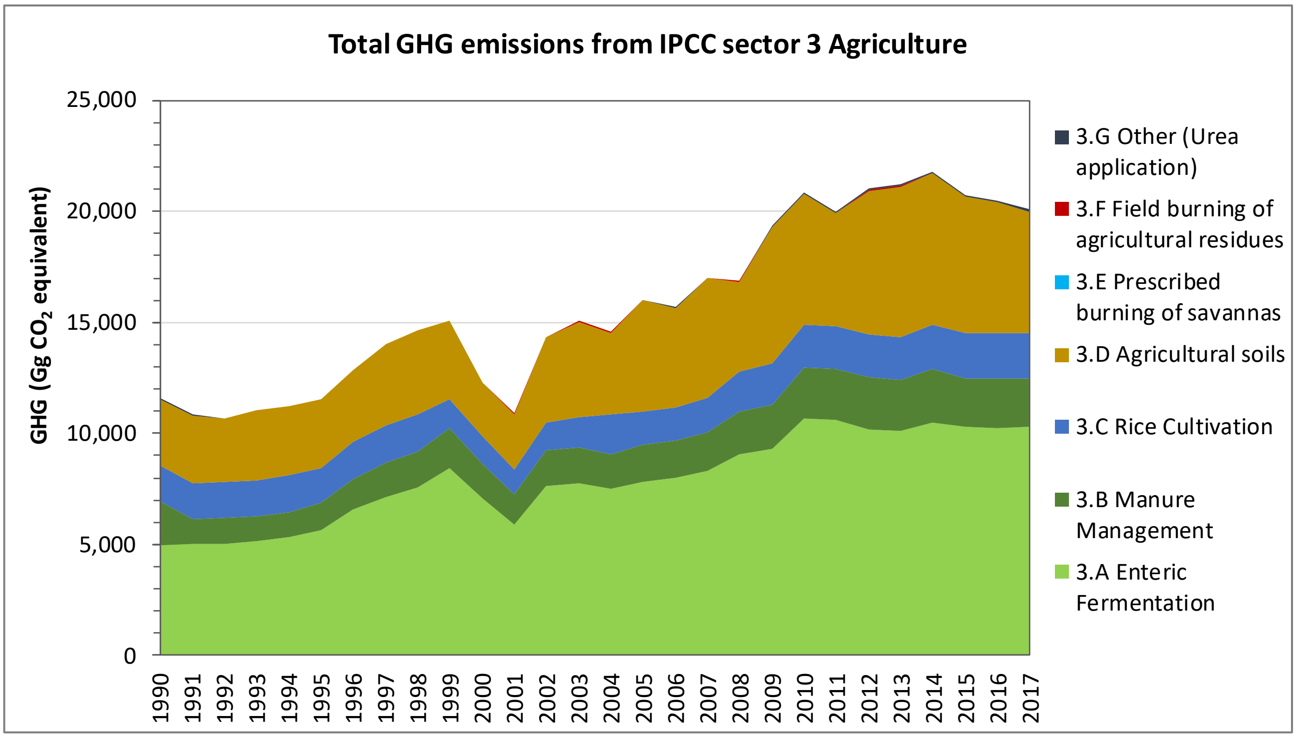


Figure 123 **Trend of GHG emissions from 1990 – 2017 for sector Agriculture**

Emission trends

In the period 1990 to 2017 GHG emissions from the Agriculture Sector increased by 73% from 11,623.10 Gg CO_2 eq in 1990 to 20,073.90 Gg CO_2 eq in 2017. Emissions from the Agriculture sector increased by 38% from 11,623.10 Gg CO_2 equivalents in 1990 to 16,036.89 Gg CO_2 equivalents in 2005. In the period 2005 to 2017 GHG emissions from the Agriculture sector increased by 25% from 16,036.89 Gg CO_2 equivalents in 2005 to 20,073.90 Gg CO_2 equivalents in 2017. The increase of emissions is mainly caused by increasing emissions from *Enteric Fermentation and Manure Management* (IPCC subcategory 3.A and 3.B) and Agricultural Soils (IPCC subcategory 3.D).

In the period 2016 to 2017 GHG emissions from the Agriculture Sector decreased by 2.1% from 20,490.89 Gg CO_2 eq in 2016 to 20,073.90 Gg CO_2 eq in 2017, which is mainly caused by decreasing emissions from cultivation activities in *Agricultural Soils* (IPCC subcategory 3.D).

The most important sources of GHGs in the Agriculture Sector is *Enteric Fermentation* and *Agricultural Soils*. With regards to CH_4 emission, the source *Enteric Fermentation* was the primary source. With regards to N_2O emission, the source *Agricultural Soils* was the primary source.

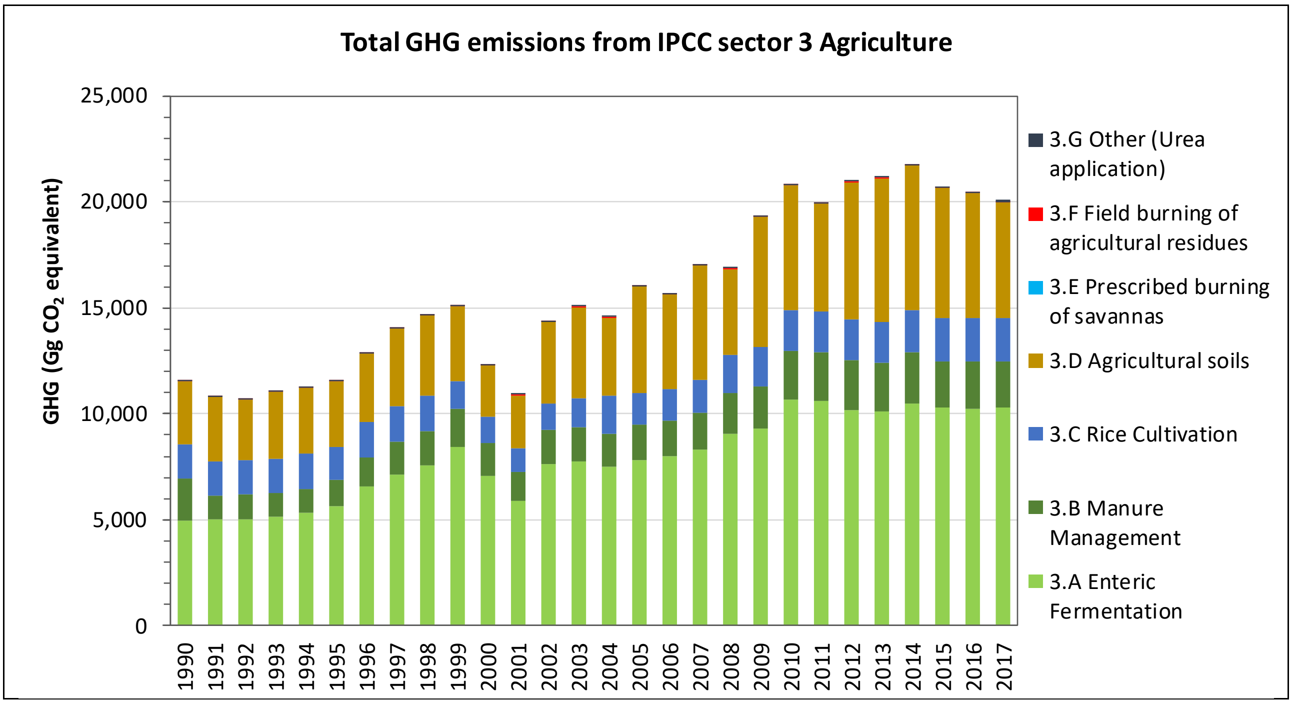


Figure 124 Total national GHG emissions by category of sector Agriculture (1990-2017)

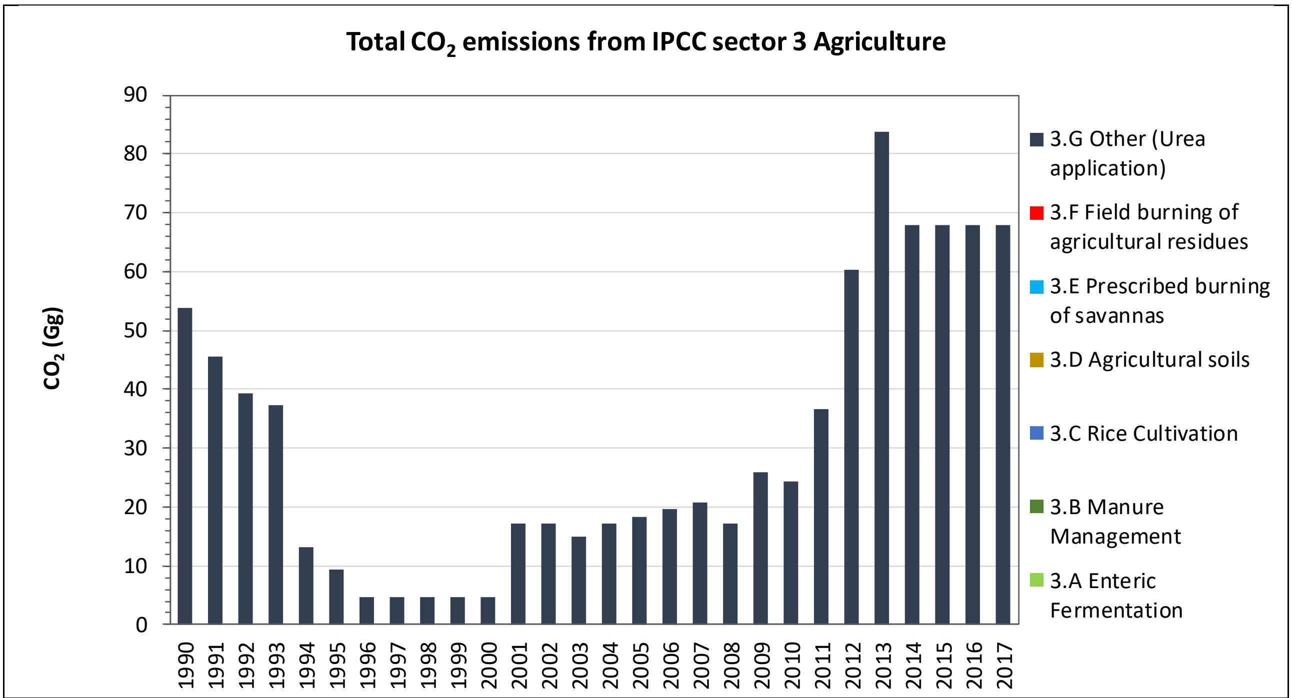


Figure 125 Total national CO_2 emissions by category of sector Agriculture (1990-2017)

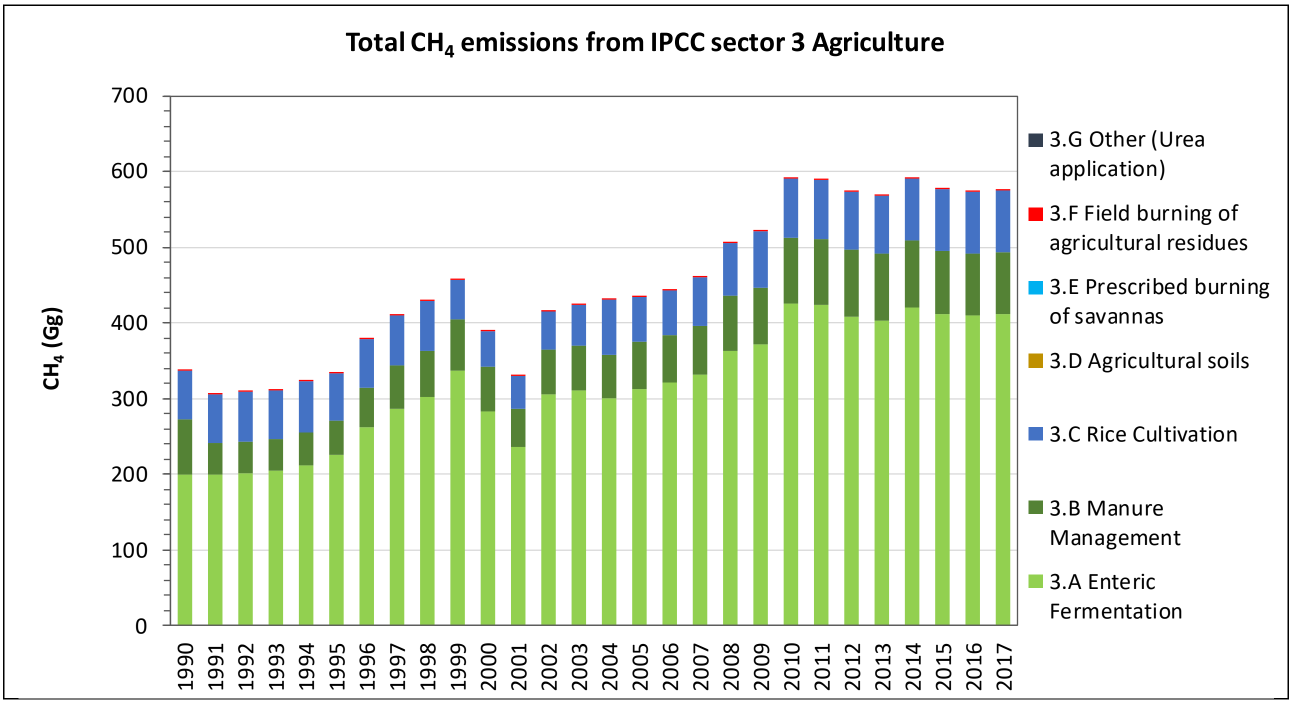


Figure 126 Total national CH_4 emissions by category of sector Agriculture (1990-2017)

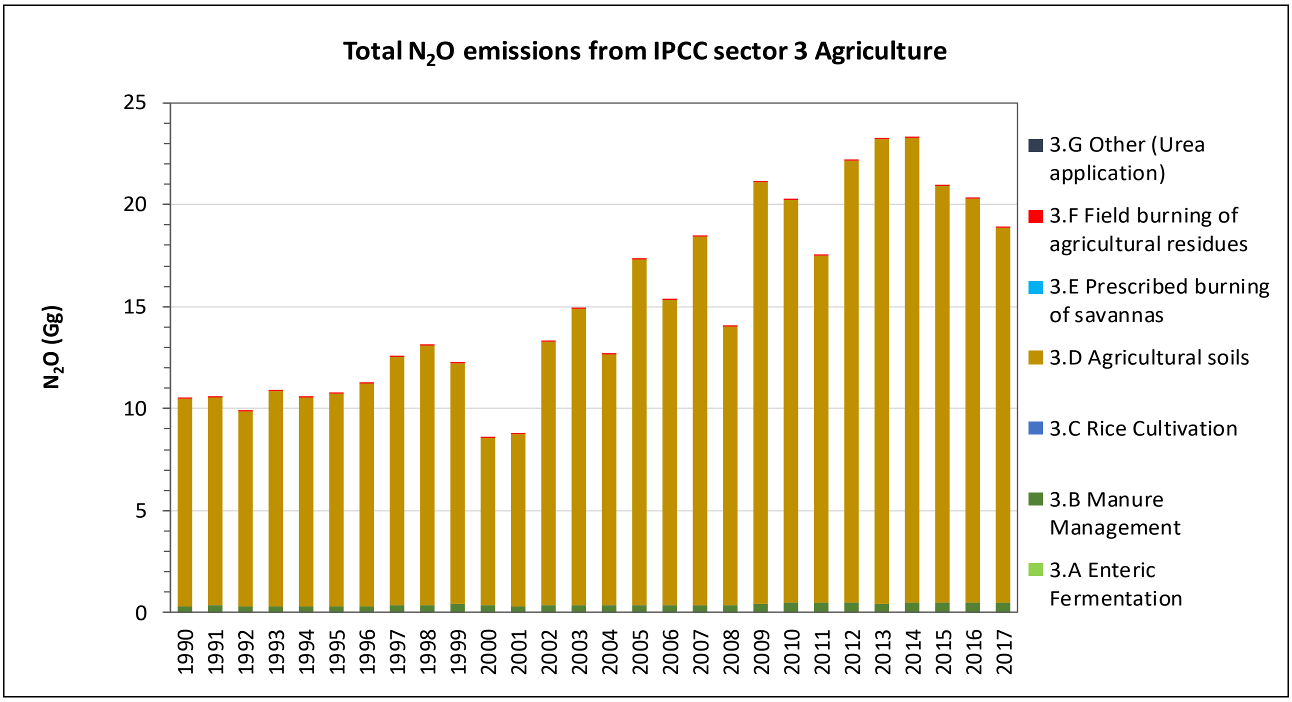


Figure 127 Total national N_2O emissions by category of sector Agriculture (1990-2017)

Table 221 Emissions from IPCC sub-category 3 Agriculture: 1990-2017

GHG emissions	TOTAL GHG	CO_2	CH_4	N_2O	CH_4	N_2O
	Gg $_{CO_2\ equivalent}$	Gg	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg	Gg
1990	11,623.10	53.73	8,451.27	3,118.10	338.05	10.46
1991	10,837.42	45.60	7,647.97	3,143.85	305.92	10.55
1992	10,694.67	39.25	7,717.15	2,938.27	308.69	9.86
1993	11,067.81	37.38	7,789.12	3,241.31	311.56	10.88
1994	11,230.07	13.08	8,067.54	3,149.45	322.70	10.57
1995	11,567.37	9.34	8,354.38	3,203.64	334.18	10.75
1996	12,848.62	4.67	9,497.62	3,346.32	379.90	11.23
1997	14,007.02	4.67	10,272.36	3,729.99	410.89	12.52
1998	14,667.86	4.67	10,757.25	3,905.94	430.29	13.11
1999	15,102.42	4.67	11,445.36	3,652.39	457.81	12.26
2000	12,302.26	4.67	9,749.19	2,548.40	389.97	8.55
2001	10,906.77	17.19	8,275.18	2,614.39	331.01	8.77
2002	14,347.23	17.19	10,372.68	3,957.35	414.91	13.28
2003	15,070.98	14.90	10,622.13	4,433.94	424.89	14.88
2004	14,574.23	17.15	10,778.45	3,778.62	431.14	12.68
2005	16,036.89	18.40	10,858.27	5,160.22	434.33	17.32
2006	15,674.66	19.54	11,088.95	4,566.17	443.56	15.32
2007	17,022.77	20.68	11,507.15	5,494.94	460.29	18.44
2008	16,863.59	17.08	12,656.53	4,189.98	506.26	14.06
2009	19,353.05	25.84	13,034.94	6,292.28	521.40	21.12
2010	20,831.46	24.32	14,774.10	6,033.04	590.96	20.25
2011	19,980.84	36.62	14,722.48	5,221.74	588.90	17.52
2012	21,006.13	60.22	14,337.03	6,608.88	573.48	22.18
2013	21,227.59	83.82	14,217.32	6,926.45	568.69	23.24
2014	21,800.63	67.92	14,798.25	6,934.47	591.93	23.27
2015	20,729.34	67.92	14,418.77	6,242.66	576.75	20.95
2016	20,490.89	67.92	14,368.56	6,054.41	574.74	20.32
2017	20,073.90	67.92	14,376.29	5,629.70	575.05	18.89
Trend						
1990 - 2017	*72.71%*	*26.41%*	*70.11%*	*80.55%*	*70.11%*	*80.55%*
2005 - 2017	*25.17%*	*269.05%*	*32.40%*	*9.10%*	*32.40%*	*9.10%*
2012 - 2017	*-4.44%*	*12.79%*	*0.27%*	*-14.82%*	*0.27%*	*-14.82%*
2016 - 2017	*-2.03%*	*0.00%*	*0.05%*	*-7.02%*	*0.05%*	*-7.02%*

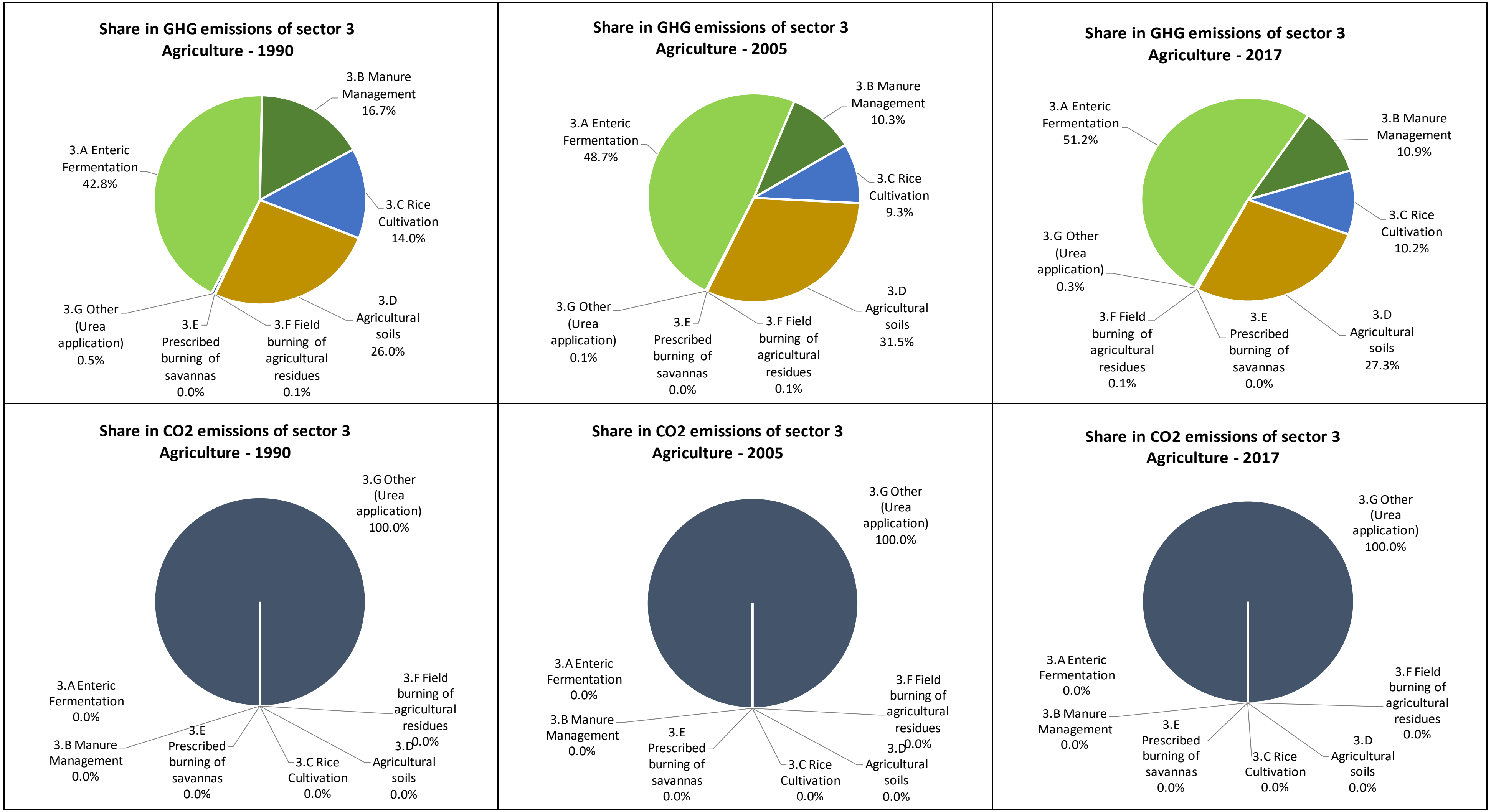


Figure 128 Share of GHG and CO_2 emissions in Sector 3 Agriculture in 1990, 2005 and 2017

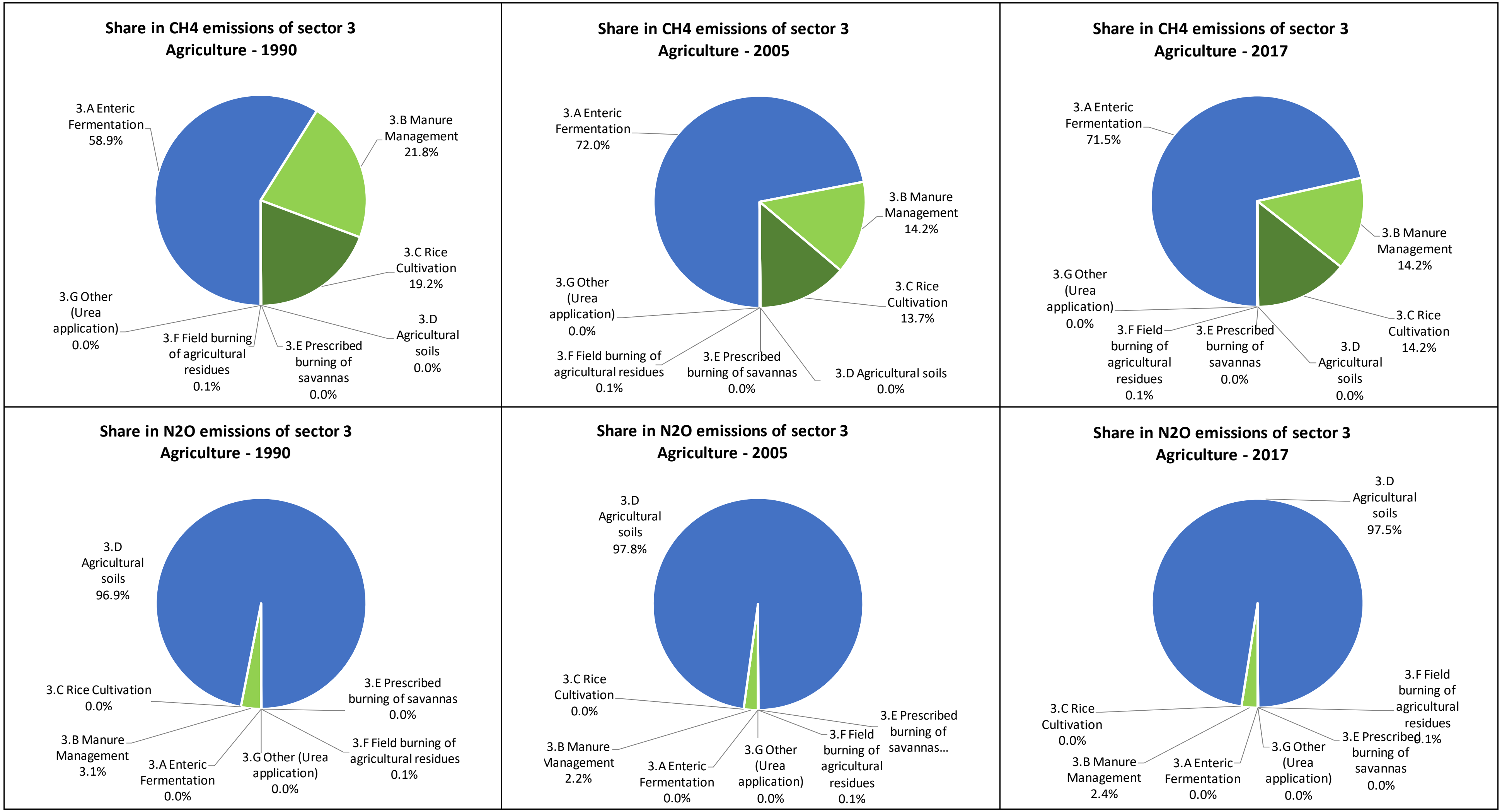


Figure 129 Share of CH_4 and N_2O emissions in Sector 3 Agriculture in 1990, 2005 and 2017

Table 222 GHG Emissions from IPCC sub-category 3 Agriculture by sub-categories

GHG emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3.G Other -Urea application
Years	Gg $_{CO_2}$ equivalent							
1990	11,623.10	4,976.19	1,940.87	1,623.18	3,020.26	NA	8.87	53.73
1991	10,837.42	4,997.17	1,139.45	1,604.63	3,041.43	NA	9.15	45.60
1992	10,694.67	5,046.97	1,135.94	1,623.18	2,840.24	NA	9.10	39.25
1993	11,067.81	5,126.89	1,120.26	1,623.18	3,150.46	NA	9.65	37.38
1994	11,230.07	5,315.36	1,159.64	1,669.55	3,061.74	NA	10.70	13.08
1995	11,567.37	5,630.95	1,226.12	1,576.80	3,112.57	NA	11.58	9.34
1996	12,848.62	6,548.59	1,414.80	1,623.18	3,246.61	NA	10.77	4.67
1997	14,007.02	7,147.83	1,551.40	1,669.55	3,621.84	NA	11.72	4.67
1998	14,667.86	7,545.00	1,645.83	1,669.55	3,790.32	NA	12.48	4.67
1999	15,102.42	8,425.41	1,835.42	1,298.54	3,527.24	NA	11.14	4.67
2000	12,302.26	7,097.63	1,547.33	1,205.79	2,439.16	NA	7.67	4.67
2001	10,906.77	5,914.00	1,330.38	1,122.31	2,515.44	NA	7.45	17.19
2002	14,347.23	7,638.51	1,580.57	1,252.17	3,846.13	NA	12.67	17.19
2003	15,070.98	7,778.74	1,597.09	1,344.92	4,320.29	NA	15.03	14.90
2004	14,574.23	7,514.48	1,557.43	1,808.68	3,662.57	NA	13.91	17.15
2005	16,036.89	7,814.80	1,656.99	1,484.05	5,044.38	NA	18.27	18.40
2006	15,674.66	8,025.76	1,672.13	1,484.05	4,456.03	NA	17.15	19.54
2007	17,022.77	8,306.41	1,718.80	1,576.80	5,382.31	NA	17.77	20.68
2008	16,863.59	9,057.54	1,942.52	1,762.31	4,068.38	NA	15.78	17.08
2009	19,353.05	9,275.17	2,012.82	1,855.06	6,161.44	NA	22.73	25.84
2010	20,831.46	10,650.74	2,317.20	1,929.26	5,887.89	NA	22.06	24.32
2011	19,980.84	10,587.69	2,316.12	1,947.81	5,074.30	NA	18.30	36.62
2012	21,006.13	10,194.85	2,360.80	1,901.44	6,466.34	NA	22.48	60.22
2013	21,227.59	10,084.85	2,346.65	1,901.44	6,785.64	NA	25.19	83.82
2014	21,800.63	10,505.79	2,369.36	2,040.57	6,790.57	NA	26.43	67.92
2015	20,729.34	10,309.18	2,188.64	2,040.57	6,099.17	NA	23.87	67.92
2016	20,490.89	10,265.21	2,182.39	2,040.57	5,911.65	NA	23.16	67.92
2017	20,073.90	10,273.23	2,183.59	2,040.57	5,487.00	NA	21.60	67.92
Trend								
1990 - 2017	*72.71%*	*106.45%*	*12.51%*	*25.71%*	*81.67%*	*NA*	*143.64%*	*26.41%*
2005 - 2017	*25.17%*	*31.46%*	*31.78%*	*37.50%*	*8.77%*	*NA*	*18.24%*	*269.05%*
2012 - 2017	*-4.44%*	*0.77%*	*-7.51%*	*7.32%*	*-15.15%*	*NA*	*-3.89%*	*12.79%*
2016 - 2017	*-2.03%*	*0.08%*	*0.05%*	*0.00%*	*-7.18%*	*NA*	*-6.71%*	*0.00%*

Table 223 CO_2 Emissions from IPCC sub-category 3 Agriculture by sub-categories

CO_2 emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3.G Other - Urea application
Years	Gg CO_2							
1990	53.73	NA	NA	NA	NA	NA	NA	53.73
1991	45.60	NA	NA	NA	NA	NA	NA	45.60
1992	39.25	NA	NA	NA	NA	NA	NA	39.25
1993	37.38	NA	NA	NA	NA	NA	NA	37.38
1994	13.08	NA	NA	NA	NA	NA	NA	13.08
1995	9.34	NA	NA	NA	NA	NA	NA	9.34
1996	4.67	NA	NA	NA	NA	NA	NA	4.67
1997	4.67	NA	NA	NA	NA	NA	NA	4.67
1998	4.67	NA	NA	NA	NA	NA	NA	4.67
1999	4.67	NA	NA	NA	NA	NA	NA	4.67
2000	4.67	NA	NA	NA	NA	NA	NA	4.67
2001	17.19	NA	NA	NA	NA	NA	NA	17.19
2002	17.19	NA	NA	NA	NA	NA	NA	17.19
2003	14.90	NA	NA	NA	NA	NA	NA	14.90
2004	17.15	NA	NA	NA	NA	NA	NA	17.15
2005	18.40	NA	NA	NA	NA	NA	NA	18.40
2006	19.54	NA	NA	NA	NA	NA	NA	19.54
2007	20.68	NA	NA	NA	NA	NA	NA	20.68
2008	17.08	NA	NA	NA	NA	NA	NA	17.08
2009	25.84	NA	NA	NA	NA	NA	NA	25.84
2010	24.32	NA	NA	NA	NA	NA	NA	24.32
2011	36.62	NA	NA	NA	NA	NA	NA	36.62
2012	60.22	NA	NA	NA	NA	NA	NA	60.22
2013	83.82	NA	NA	NA	NA	NA	NA	83.82
2014	67.92	NA	NA	NA	NA	NA	NA	67.92
2015	67.92	NA	NA	NA	NA	NA	NA	67.92
2016	67.92	NA	NA	NA	NA	NA	NA	67.92
2017	67.92	NA	NA	NA	NA	NA	NA	67.92
Trend								
1990 - 2017	*26.41%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*26.41%*
2005 - 2017	*269.05%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*269.05%*
2012 - 2017	*12.79%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*12.79%*
2016 - 2017	*0.00%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0.00%*

Table 224 CH_4 Emissions from IPCC sub-category 3 Agriculture by sub-categories

CH_4 emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3.G Other (Urea application)
Years	Gg CH_4							
1990	338.05	199.05	73.79	64.93	NA	NO	0.28	NA
1991	305.92	199.89	41.55	64.19	NA	NO	0.29	NA
1992	308.69	201.88	41.59	64.93	NA	NO	0.29	NA
1993	311.56	205.08	41.25	64.93	NA	NO	0.31	NA
1994	322.70	212.61	42.96	66.78	NA	NO	0.34	NA
1995	334.18	225.24	45.50	63.07	NA	NO	0.37	NA
1996	379.90	261.94	52.68	64.93	NA	NO	0.35	NA
1997	410.89	285.91	57.81	66.78	NA	NO	0.39	NA
1998	430.29	301.80	61.30	66.78	NA	NO	0.41	NA
1999	457.81	337.02	68.49	51.94	NA	NO	0.36	NA
2000	389.97	283.91	57.59	48.23	NA	NO	0.24	NA
2001	331.01	236.56	49.32	44.89	NA	NO	0.24	NA
2002	414.91	305.54	58.87	50.09	NA	NO	0.41	NA
2003	424.89	311.15	59.45	53.80	NA	NO	0.49	NA
2004	431.14	300.58	57.78	72.35	NA	NO	0.43	NA
2005	434.33	312.59	61.78	59.36	NA	NO	0.60	NA
2006	443.56	321.03	62.62	59.36	NA	NO	0.55	NA
2007	460.29	332.26	64.36	63.07	NA	NO	0.60	NA
2008	506.26	362.30	72.98	70.49	NA	NO	0.49	NA
2009	521.40	371.01	75.45	74.20	NA	NO	0.74	NA
2010	590.96	426.03	87.06	77.17	NA	NO	0.71	NA
2011	588.90	423.51	86.90	77.91	NA	NO	0.58	NA
2012	573.48	407.79	88.90	76.06	NA	NO	0.73	NA
2013	568.69	403.39	88.44	76.06	NA	NO	0.80	NA
2014	591.93	420.23	89.24	81.62	NA	NO	0.84	NA
2015	576.75	412.37	82.01	81.62	NA	NO	0.75	NA
2016	574.74	410.61	81.79	81.62	NA	NO	0.73	NA
2017	575.05	410.93	81.83	81.62	NA	NO	0.67	NA
Trend								
1990 - 2017	*70.11%*	*106.45%*	*10.89%*	*25.71%*	*NA*	*NA*	*136.42%*	*NA*
2005 - 2017	*32.40%*	*31.46%*	*32.45%*	*37.50%*	*NA*	*NA*	*12.39%*	*NA*
2012 - 2017	*0.27%*	*0.77%*	*-7.96%*	*7.32%*	*NA*	*NA*	*-7.89%*	*NA*
2016 - 2017	*0.05%*	*0.08%*	*0.05%*	*0.00%*	*NA*	*NA*	*-7.31%*	*NA*

Table 225 N_2O Emissions from IPCC sub-category 3 Agriculture by sub-categories

N_2O emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3.G Other (Urea application)
	Gg N_2O							
1990	10.46	NA	0.32	NO	10.14	NO	0.01	NA
1991	10.55	NA	0.34	NO	10.21	NO	0.01	NA
1992	9.86	NA	0.32	NO	9.53	NO	0.01	NA
1993	10.88	NA	0.30	NO	10.57	NO	0.01	NA
1994	10.57	NA	0.29	NO	10.27	NO	0.01	NA
1995	10.75	NA	0.30	NO	10.44	NO	0.01	NA
1996	11.23	NA	0.33	NO	10.89	NO	0.01	NA
1997	12.52	NA	0.36	NO	12.15	NO	0.01	NA
1998	13.11	NA	0.38	NO	12.72	NO	0.01	NA
1999	12.26	NA	0.41	NO	11.84	NO	0.01	NA
2000	8.55	NA	0.36	NO	8.19	NO	0.01	NA
2001	8.77	NA	0.33	NO	8.44	NO	0.00	NA
2002	13.28	NA	0.37	NO	12.91	NO	0.01	NA
2003	14.88	NA	0.37	NO	14.50	NO	0.01	NA
2004	12.68	NA	0.38	NO	12.29	NO	0.01	NA
2005	17.32	NA	0.38	NO	16.93	NO	0.01	NA
2006	15.32	NA	0.36	NO	14.95	NO	0.01	NA
2007	18.44	NA	0.37	NO	18.06	NO	0.01	NA
2008	14.06	NA	0.40	NO	13.65	NO	0.01	NA
2009	21.12	NA	0.42	NO	20.68	NO	0.01	NA
2010	20.25	NA	0.47	NO	19.76	NO	0.01	NA
2011	17.52	NA	0.48	NO	17.03	NO	0.01	NA
2012	22.18	NA	0.46	NO	21.70	NO	0.01	NA
2013	23.24	NA	0.46	NO	22.77	NO	0.02	NA
2014	23.27	NA	0.46	NO	22.79	NO	0.02	NA
2015	20.95	NA	0.46	NO	20.47	NO	0.02	NA
2016	20.32	NA	0.46	NO	19.84	NO	0.02	NA
2017	18.89	NA	0.46	NO	18.41	NO	0.02	NA
Trend								
1990 - 2017	*80.55%*	*NA*	*43.53%*	*NA*	*81.67%*	*NA*	*172.93%*	*NA*
2005 - 2017	*9.10%*	*NA*	*22.55%*	*NA*	*8.77%*	*NA*	*44.70%*	*NA*
2012 - 2017	*-14.82%*	*NA*	*-0.30%*	*NA*	*-15.15%*	*NA*	*13.41%*	*NA*
2016 - 2017	*-7.02%*	*NA*	*0.11%*	*NA*	*-7.18%*	*NA*	*-4.56%*	*NA*

5.1 Agricultural data collected and used

5.1.1 Sources of data

The original data provider for the national and international agricultural data is the Ministry of Agriculture Irrigation and Livestock (MAIL). The agricultural data used and presented in this inventory are taken from the following national and international sources:

Afghanistan National Livestock Census[127] In 2003 the Afghanistan National Livestock Census was conducted by the Food and Agriculture Organization of the United Nations (FAO) and Ministry of Agriculture Irrigation and Livestock (MAIL) aimed to narrow the data and information gap on livestock. (FAO 2008).

Afghanistan Statistical yearbook[128] The official statistics (several years) of NSIA provides information on

- usable land area and cultivated land area
- crop production, crop yield of agricultural products
- fruit and vegetable cultivated land area
- fruit area and production by province
- area and production of wheat, rice , barley, maize by province
- annual livestock numbers
- saffron area , production and yield
- area and production of cotton by region
- livestock production by type

for the last decade or more and are published in chapter Agriculture Development of the statistical yearbooks.

CountrySTAT[129] CountrySTAT is a web-based information system for food and agriculture statistics provided by NSIA.

FAO agricultural data base[130] The FAO agricultural data base (FAOSTAT) provides worldwide harmonized data (FAO AGRICULTURE STATISTICAL SYSTEM 2001).[131] The FAO data base provides data for the entire time series 1990 – 2017, even some data are based on estimates done by FAO.

FAO land cover data **databases and maps:** are available and relevant shape file can be downloaded from the FAO website[132].

- Land cover database for 1993 Available on FAO website[133]
- Land cover database for 2010 Available on FAO website [134]
- Land cover database for 2016 Based on 2010 database.[135]

[127] Available (03. March 2019) on http://www.fao.org/3/i0034e/i0034e00.htm
[128] Available (03. March 2019) on https://www.nsia.gov.af/library
[129] Available (03. March 2019) on http://afghanistan.countrystat.org/home/en/
[130] Available (03. March 2019) on http://www.fao.org/statistics/en/
[131] http://www.fao.org/faostat/en/#data
[132] http://dwms.fao.org/~draft/lc_main_en.asp
[133] FAO (1993): Available on 20.04.2019 at: http://www.fao.org/geonetwork/srv/en/main.home?uuid=c1b18130-88fd-11da-a88f-000d939bc5d8
[134] FAO (2012): Available on 20.04.2019 at: http://www.fao.org/geonetwork/srv/en/main.home?uuid=5879a4f0-8fdf-4c93-b39a-02d6ce69ae6d
[135] FAO (2016): Available (14.04.2019) on http://www.fao.org/3/a-i5043e.pdf

Additional national publications such as the ALCS were used to cross-check the above-mentioned statistics but a direct use of these publications was not possible:

- Afghanistan Living Conditions Survey (ALCS) 2016-2017[136];
- Afghanistan Living Conditions Survey (ALCS) 2013-2014[137];
- Afghanistan Living Conditions Survey (ALCS) 2011-2012[138];
- National and Assessment Vulnerability 2008/2007[139];
- Afghanistan Living Conditions Survey (ALCS) 2005[140].

All national and international data are compared and discussed with national experts from Ministry of Agriculture Irrigation and Livestock (MAIL), National Statistics and Information Authority (NSIA), National Protection Agency (NEPA), Independent Directorate of Local Governance (IDLG), Municipality of Kabul, and University of Kabul and Kabul Polytechnic University.

The results of these QA/QC checks are presented in the following chapters under "Source-specific QA/QC and verification".

5.1.2 Country-specific issues

With a varied geography and topography, out of 652,000 km2 of total land area in Afghanistan, only an estimated 12% is arable, 3% of the land is considered forest-covered, 46% is under permanent pasture and 39% is mountainous, not usable for agriculture (CSO 2014).

According to the Country Programming Framework (CPF) 2012-2015 for the Islamic Republic of Afghanistan[141] the major constraints to agriculture are:

(1) Limited availability of arable land:
- only 12% of total land is suitable for cultivation, due to the dominance of mountainous craggy terrain;
- 45% of the land is "rangeland".
- Arable land comprises 3.5 million ha of irrigated land and 3,7 million ha are rain-fed (non-irrigated).

(2) Limited access to water:
- average annual rainfall of around 300 mm mainly (70%) concentrated in the winter months
- precipitation is mostly in the form of snowfall in high altitudes
  - The snow is a 'natural reserve' to partly fulfil the crop water requirement in low-lands during growth stage of crops.
- In early spring more floods and later on shortage of water/ drought hit most part of the country.
- Out of average 57 billion m^3 annual surface water resources available, Afghanistan uses only about 30 % for irrigation with poor levels of efficiency. Traditional irrigation methods (canals, karezes, springs and wells) absorb more than 90% of water supply for irrigation, which allies with high wastages of water.

(3) Low productivity
- low productivity of crops, livestock and forestry prevails
- prevalence of small per-capita holdings;
- inadequate regulating water resources infrastructures (reservoirs/dams);
- poor irrigation and water management;

[136] Available (14.04.2019) on https://www.nsia.gov.af:8080/wp-content/uploads/2019/04/ALCS-2016-17-Analysis-report-.pdf
[137] Available (14.04.2019) on https://www.nsia.gov.af:8080/wp-content/uploads/2019/04/AFGHANISTAN-LIVING-CONDITIONS-SURVEY-2014.pdf
[138] Available (14.04.2019) on https://www.nsia.gov.af:8080/wp-content/uploads/2019/04/AFGHANISTAN-LIVING-CONDITIONS-SURVEY-2011-12.pdf
[139] Available (14.04.2019) on https://www.nsia.gov.af:8080/wp-content/uploads/2019/04/Afghanistan-Living-Conditions-Survey-2007-8.pdf
[140] Available (14.04.2019) on https://www.nsia.gov.af:8080/wp-content/uploads/2019/04/AFGHANISTAN-LIVING-CONDITIONS-SURVEY-2005.pdf
[141] FAO (2012): Country Programming Framework (CPF) for the Islamic Republic of Afghanistan - 2017 to 2021, July 2017. Available (14.01.2019) on http://www.fao.org/3/a-bl941e.pdf

- inadequate land management;
- use of obsolete technology; inadequate land preparation;
- inadequate use of improved seed, fertilizer and pesticides;
- limited crop diversification (excessive focus on wheat);
- inadequate crop rotation;
- depletion of rural infrastructures;
- inadequate skills among herders and farmers on veterinarian treatments;
- insufficient production and inadequate quality of forage and feed for domestic animals;
- conflicts regarding traditional grazing rights and land use;
- low skills among input providers on contagious animal diseases and zoonotic diseases;
- low quality/safety control of products of animal origin and low quality of inputs (counterfeit and sub-standard medicines and vaccines);
- decreased pasture due to continuous drought and overgrazing and breakdown/conversions of rangelands to rain-fed land for certain crops;
- inadequacy of social services;
- weaknesses of producer organizations;
- lack of legislative, financial and technical support.

(4) Inadequacies in post-harvest operations, infrastructure, quality of production and food safety

- improper handling, threshing and cleaning, and poor storage;
- lack of skills for quality processing;
- poor quality control, also for food safety;
- limited transport facilities;
- insufficient milling capacity;
- lack of good packaging or labelling equipment;
- inadequate hygiene practices;
- lack of cold chains.

(5) Shortfalls in commercialization of agricultural products

- limited value addition to agricultural production, shortage of business planning, management and marketing skills;
- weak links between farmers/producers, wholesalers, and consumers or exporters;
- limited access to and use of market information;
- inadequate access to credit and financial services;
- limited working capital; non-tariff trade barriers;
- inadequate legislation and regulations for the promotion of private sector, including requirements for standards and certification system;

market distortions due to uncoordinated, inadequately planned or uncalled use of emergency inputs, such as competition of free seed distribution of seeds, fertilizer, vaccines, tools and other productive inputs.

In the following table and figures are provided an overview of the Land cover 2010 for Afghanistan[142].

[142] Source: Land Cover Atlas of Afghanistan; FAO 2016; Available (17.02.2019) on http://www.fao.org/3/a-i5043e.pdf

Table 226 Land Cover of Afghanistan in 2010

2010 LAND COVER	HECTARAGE	% OF AFG
Settlements / BUILT-UP	**306,855**	**0.48**
1A: Urban	280,478	0.44
1B: Non-Urban	26,377	0.04
ARABLE LAND, FOREST & RANGELAND	**39,559,826**	**61.28**
ARABLE LAND	**7,534,796**	**11.67**
2A: FRUIT TREES	**117,642**	**0.18**
2B: VINEYARD	**82,450**	**0.13**
IRRIGATED AGRICULTURAL LAND	**2,490,480**	**3.87**
3A: Intensively cultivated (2 Crops/Year)	349,618	0.54
3A1: Intensively Cultivated (1 or 2 Crops/Year)	1,887,106	2.93
3C: Active Karez System Agriculture	253,756	0.39
MARGINAL AGRICULTURAL LAND	**1,109,730**	**1.72**
3B: Poorly irrigated / Non active Karez		
RAINFED	**3,734,494**	**5.8**
4A: Flat lying Areas	906,273	1.41
4B: Sloping Areas	2,828,221	4.39
FORESTS	**1,781,045**	**2.76**
NATURAL NEEDLE LEAVED FORESTS	**975,041**	**1.51**
6A: Closed Needleaved Trees	83,277	0.13
6B: Open Needleaved Trees	891,764	1.38
6B1: Closed to Open Undifferentiated Trees	**234,399**	**0.36**
6C: High Shrubs	**571,605**	**0.89**
7: RANGELAND	**30,243,985**	**46.97**
BARE AREAS	**22,183,289**	**34.45**
8A: Bare Soil / Rock Outcrops	17,404,540	27.03
8B: Sand Covered Areas	2,008,008	3.12
8C: Sand Dunes	2,770,741	4.3
MARSHLAND	**410,796**	**0.64**
9A: Permanent Marsh	98,552	0.15
9B: Seasonally Inundated Vegetation	312,244	0.48
WATER BODIES, RIVER, RIVERBANK, SNOW COVERED AREA	**1,932,415**	**2.99**
WATER BODIES	**408,835**	**0.63**
10A: Permanent Lake	96,426	0.15
9B: Seasonal Lake	312,409	0.49
11: RIVER	**128,438**	**0.2**
12: RIVERBANK	**897,906**	**1.39**
13: SNOW COVERED AREA	**497,236**	**0.77**
TOTAL	**64,559,000**	

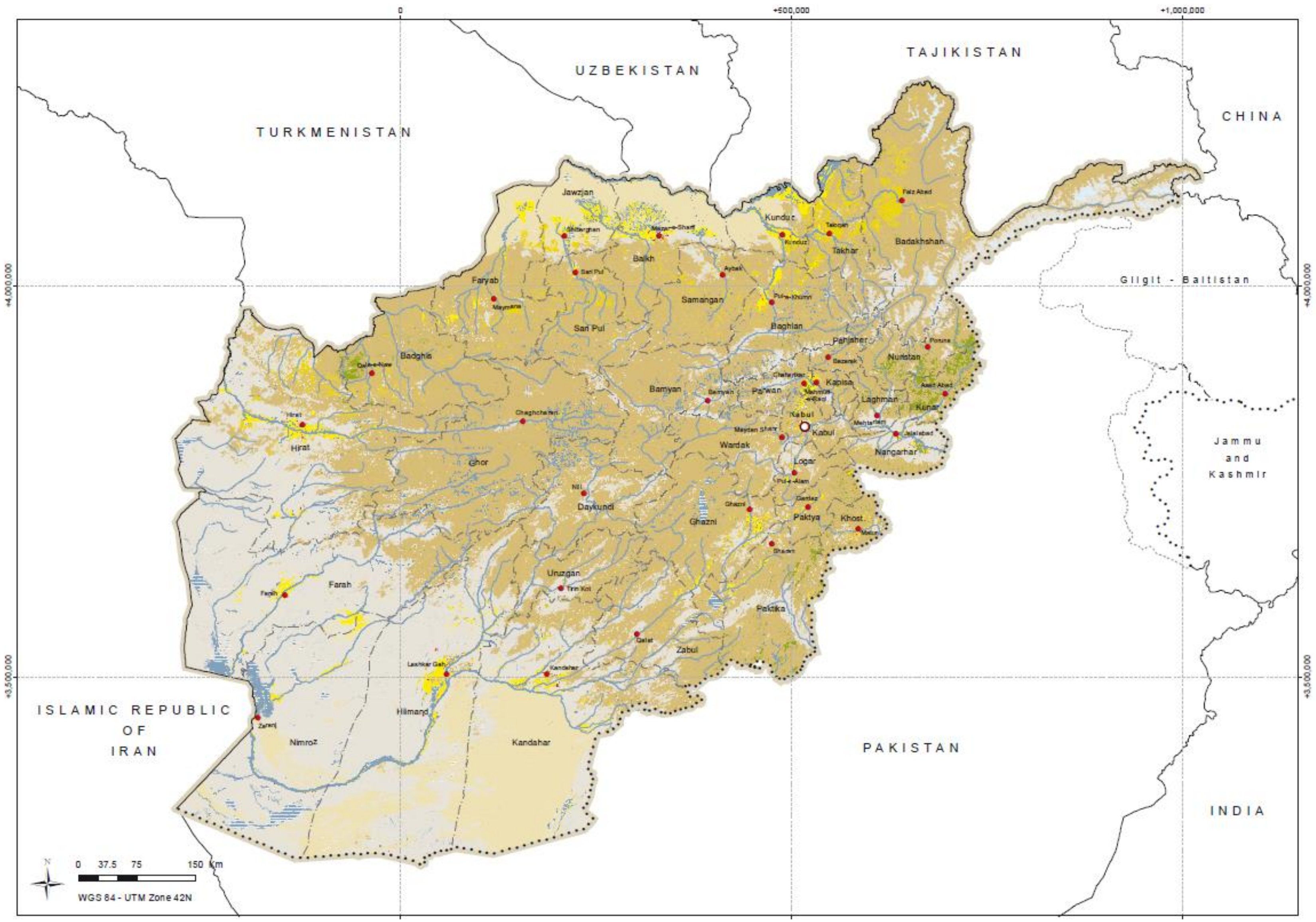


Figure 130 **Land Cover of Afghanistan in 2010**

Source: Land Cover Atlas of Afghanistan; FAO 2016; Available (17.02.2019) on http://www.fao.org/3/a-i5043e.pdf

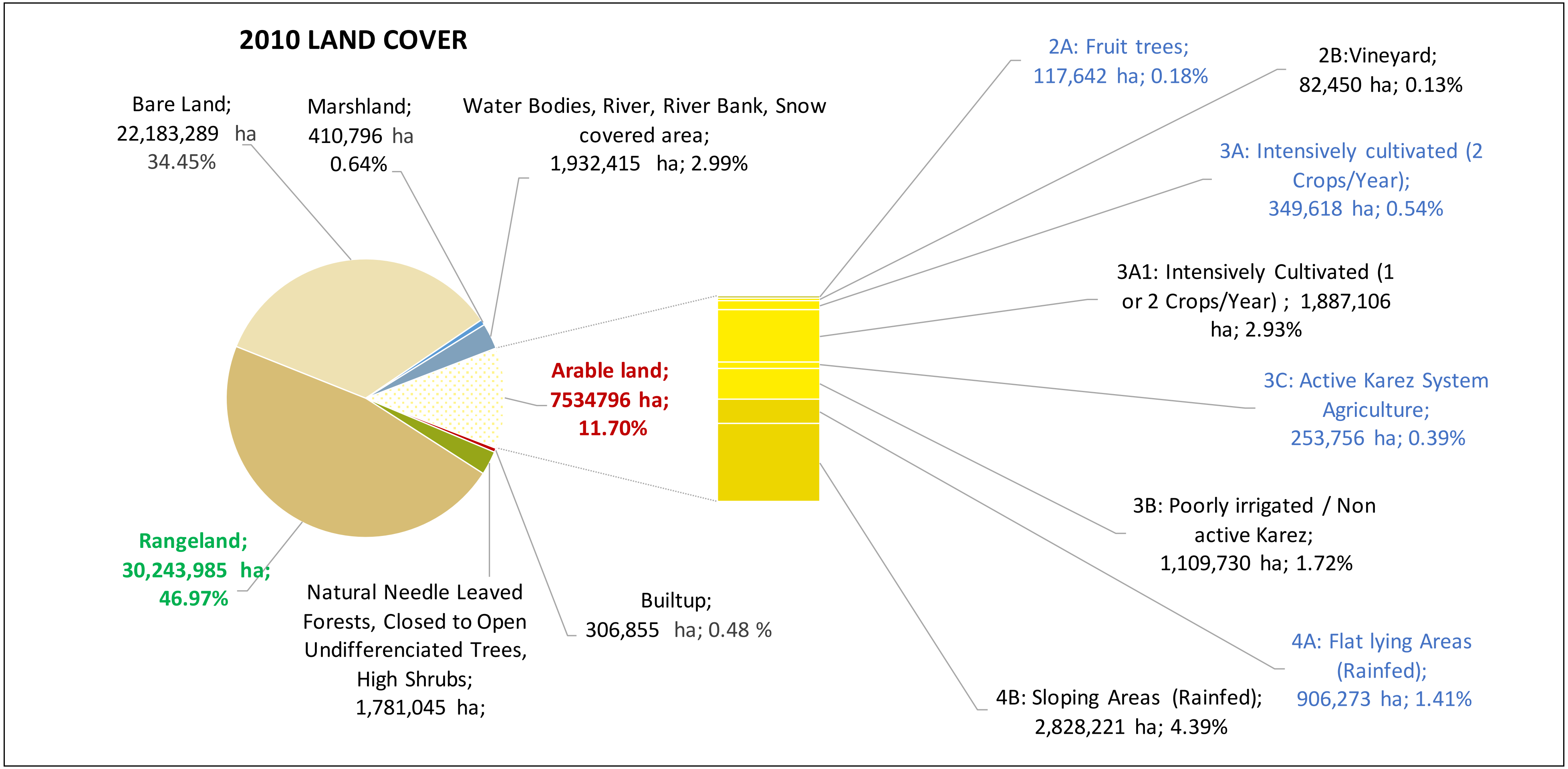


Figure 131 **Land Cover with focus on Arable land of Afghanistan**

Source: Land Cover Atlas of Afghanistan; FAO 2016; Available (17.02.2019) on http://www.fao.org/3/a-i5043e.pdf

As stated in the ALCS 2016-2017 the sector Agriculture – covering both farming and livestock-related activities – is the backbone of Afghanistan's economy. For 44.2% of households, agriculture provides any source of income and for 28.0% it is even the most important source. Similarly, with almost 45% of the employed engaged in agriculture, it is the main sector for employment. NSIA estimates that the sector agriculture contributed 23% to the country's GDP in the solar year 1395 (2016-17) (CSO 2017). However, the capacity of the agriculture sector is restricted by droughts, a partially destroyed infrastructure and shrinking grazing land.

In 2017 agriculture currently contributes about 23.7% of total GDP and hereof livestock contributes about 2.8% of total GDP, cereals cultivation about 7.5% and fruits about 3.6% (NSIA 2018).

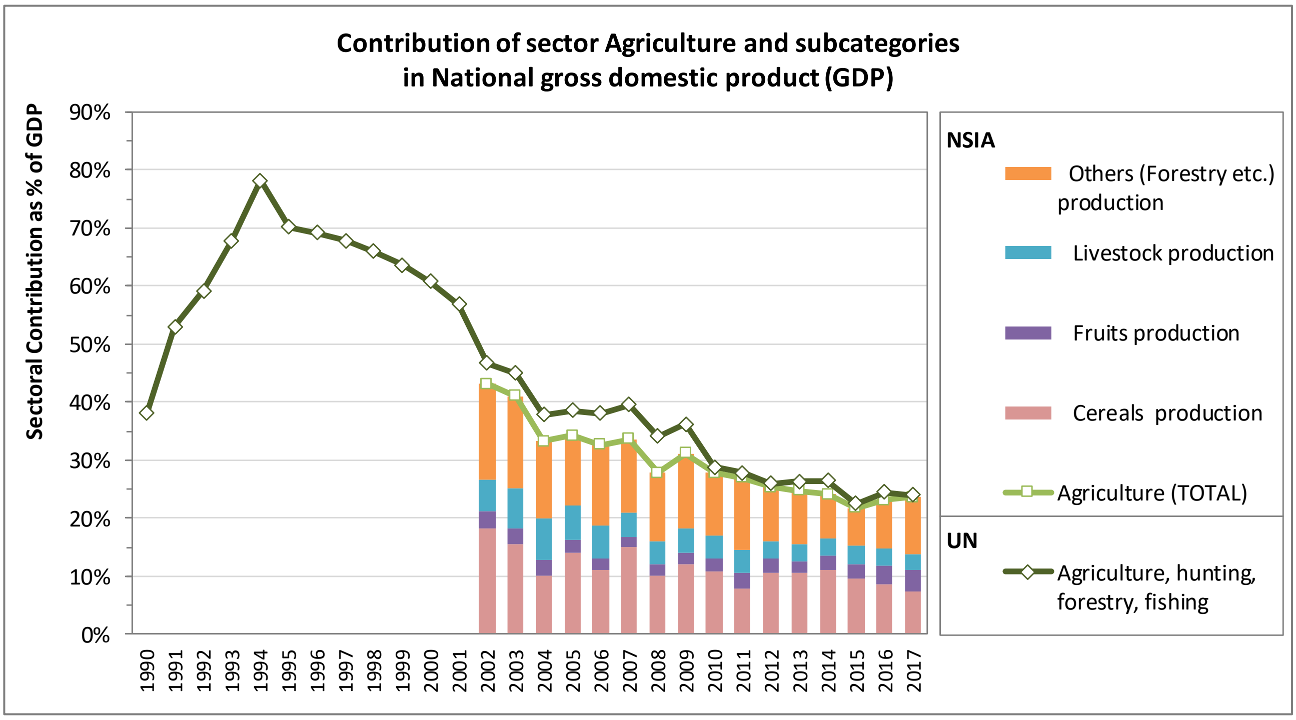


Figure 132 **Contribution of sector Agriculture and subcategories in national GDP**

Source: NSIA 2018, UNSD[143]

Afghanistan exports some livestock products—mostly skins, wool, and cashmere—but it imports much larger amounts (by value) of live animals, meats, eggs, and dairy products. The demand for these imported products has more than doubled since 2008 and has been almost entirely met from imports.

[143] Available on http://data.un.org/Data.aspx?d=SNAAMA&f=grID%3a202%3bcurrID%3aUSD%3bpcFlag%3a0

5.1.3 Livestock

As it is stated in the Afghanistan Living Conditions Survey (ALCS) 2016-2017 the economy of Afghanistan is dominated by the agricultural sector. Almost 45% of the employed population – representing 2.8 million people – is engaged in work in the farming or livestock sub-sectors. Employment within this economic sector is evenly distributed between the sub-sectors of farming (23.2% of total employment) and livestock production (21.2% of total employment).

As described in the ALCS 2016-2017 the livestock subsector can be divided into **sedentary and nomadic production systems**.

> The nomadic system provides the main source of livelihood for many of the poorest people, especially the nomads, and accounts for most of the red meat, skins, and wool that reach the market. Nomadic livestock husbandry is a low productivity activity that is particularly prone to losses from drought and severe winters.
>
> The sedentary system consists of settled farmers, who hold some sheep and goats and most of the cattle on small agricultural holdings. The intensity of livestock farming on sedentary farms is conditioned mainly by the availability of irrigation for producing fodder, forage, and other feeds (crop by-products, such as wheat- and barley-straw).

Livestock provides an exclusive livelihood for Afghanistan's nomads, who follow traditional grazing routes across the country. As in the Afghanistan Ministry of Agriculture, Animal Husbandry and Food Master Plan (2006)[144] is stated that **extensive livestock production** occurs over vast areas of the country and includes a large population of nomadic herders. Rangelands cover around 45% of the total land area in Afghanistan. However, large areas that are considered barren or "wasteland" are also used for grazing, particularly in the winter. The total graze-able area therefore is much larger, estimated at 70-85% of the total land area.

Pastoralism is a social and economic system based on the raising and herding of livestock, including migration to utilize to the maximum seasonal available pasture for the livestock. In Afghanistan occurs three categories of pastoralism:

1. Migratory, livestock dependent societies (e.g. pastoralists)
2. Recently settled, formerly migratory livestock dependent (e.g. former pastoralists)
3. Settled people, that still hold on to the cultural identity and refer to themselves as "kuchi."

In general, low productivity breeds, diseases, poor feeding, drought, and the difficulties of marketing perishable commodities are the main constraints on the livestock subsector. These constraints are most difficult to overcome in the widely dispersed nomadic and subsistence-oriented sedentary systems. It is the farmers in areas with easy access to irrigated land and urban markets who have the best prospects for producing dairy, poultry meat, and eggs on a commercial basis to compete with imports in supplying the rapidly growing urban market. Most of these better-placed farmers produce at small scales, though some larger-scale units exist for dairy and commercial poultry production (milk, egg layers, and broilers)(ALCS 2017-2018).

In the following table an overview of agricultural products is provided.

[144] https://afghanag.ucdavis.edu/country-info/files/usaid-masterPlan.pdf

Table 227 Agricultural products in 1990, 2005, 2010 and 2017

Product/Source		Unit	1990	2005	2010	2017
Milk	**Cattle**	tons	560,000	1,458,000	1,401,000	1,787,442
	Sheep	tons	212,550	167,059	200,000	206,675
	Goats	tons	51,000	105,000	112,000	114,701
	Camel	tons	6,600	7,700	8,000	6,824
Eggs		1000 No	286,000	436,000	326,880	400,000
Meat	**Cattle**	tons	86,400	141,100	131,000	93,690
	Sheep	tons	114,992	88,000	113,000	112,568
	Goats	tons	30,000	45,500	44,200	46,780
	Camel	tons	3,240	3,780	3,960	3,656
	Game	tons	86,400	141,100	131,000	93,690
	Chicken	tons	12,400	32,320	28,000	27,871
Wool		tons	**	12,900	15,900*	**
Hides, cattle, fresh		tons	**	15,680	14,556*	**
Skins, goat, fresh		tons	**	8,750	8,500*	**
Skins, sheep, fresh		tons	**	13,750	17,750*	**
Silk-worm cocoons, relabel		tons	**	529	597*	651
Cashmere		tons	**	**	**	**
Karakul pelts		No.	**	**	**	**
Honey		tons	3,244	2,500	2,000	1,470
*** Data not available*						
Source			FAO	FAO	NSIA / *FAO	FAO

Besides the use of livestock for food security and transportation the extent of draught power for agricultural operations is very large in Afghanistan.

Many Afghans raise livestock while also growing crops. Overall, livestock herds significantly decreased between 1977 and 2004. This was partly because many pastoral nomads took refuge in Pakistan during the conflicts. Other reasons included lack of access to summer grazing areas in Central Afghanistan, years of severe drought, poor animal husbandry, and poor disease control. Livestock numbers have rebounded since 2004, with the return of some owners and their animals to the country.[145]

Further fluctuations are due to extensive droughts (e.g. 2012) and long winter with a lot of snow (e.g. 2008 – 2010) but also diseases.

The increase in number of livestock in the past and the present is due to implementation of national and international projects and services to the farmers in respect to

- Animal health service delivery
- Disease prevention and control
- Veterinary Public Health
- Animal health extension
- Strengthen animal breeding policy and research

[145] WORLDBANK (2014): Islamic Republic of Afghanistan. Agricultural Sector Review. Revitalizing Agriculture for Economic Growth, Job Creation and Food Security. Report No: AUS9779. Washington.

- Increased availability and quality of animal feed
- A shift towards semi/commercialization
- Animal production extension

These project and services are summarized in the National Comprehensive Agriculture Development Priority Program 2016 – 2021[146] which is the strategic framework for the agriculture sector development and reform.

5.1.3.1 Cattle

In 2017 about 4,977,000 cattle were existing in Afghanistan:

- ~ 3,579,000 were dairy cattle:
  - high-producing and low-producing cows that have calved at least once and are used principally for milk production
- ~ 1,656,000 were calves, oxen, bulls, and bovines;
  - Females:
    - cows used to produce offspring for meat;
    - cows used for more than one production purpose: milk, meat, draft;
  - Males:
    - bulls used principally for breeding purposes;
    - bullocks used principally for draft power;
  - Growing Cattle
    - calves pre-weaning;
    - replacement dairy heifers;
    - growing / fattening cattle post-weaning;
    - feedlot-fed cattle on diets containing > 90 % concentrates.

In Afghanistan cattle are quite important for milk production and cultivation of land, although there is trend for mechanization of agricultural operations. Oxen still find a place at the small farmers level, but milk production is likely to become more important with the advancement in mechanization.

As described in ULFAT-UN-NABI KHAN & MUZAFFAR IQBAL (2001)[147] the management of cattle varies, however, the milking cows are kept in confinement and during summer and spring season they are offered fresh alfalfa and clover. During the winter season cattle are fed straw, hay and corn stalks. Supplementary feeding with cotton seed cake, barley and corn (grain or flour) is also provided. Dry cows, young stock and males are usually sent to hills during the summer. During this period these animals are managed by the community and the cows are bred through natural mattings.

The cattle breeds include Afghan Kabuli, Badakhshani Bouy, Badakhshani Dasnier, Kandahari or Qandahari, Konari, Shankhansurri, Systani and crosses between native and exotic breeds (Friesian, Jersey and Brown Swiss). Kandahari and Systani breeds are large sized while Konari breed is medium sized. The Afghan cattle present a large phenotypic variation in size and colour (generally black or brown). Small cattle found in the mountains and Badakhshan province may weigh below 200 kg while larger cattle are mostly kept in Herat and Kandahar area due to better feeding and management conditions.

[146] MAIL (2016) http://extwprlegs1.fao.org/docs/pdf/afg167994.pdf

[147] Ulfat-un-Nabi Khan & Muzaffar Iqbal (2001): Role and the size of livestock sector in Afghanistan: A Study Commissioned by The World Bank, Islamabad. Available (03.01.2019) http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.202.5064&rep=rep1&type=pdf

5.1.3.2 Sheep and goats

In 2017 about 13,866,000 sheep were existing in Afghanistan:

- ~ 7,139,000 mature ewes:
  - breeding ewes for production of offspring and wool production
  - milking ewes where commercial milk production is the primary purpose
- ~ 6,126,000 were growing lambs and other mature sheep (>1 year).

In 2017 about 13,866,000 goats were existing in Afghanistan:

- ~ 2,637,000 mature ewes:
  - breeding ewes for production of offspring
  - milking ewes where commercial milk production is the primary purpose
- ~ 4,811,000 were growing lambs and other mature goats (>1 year).

As described in ULFAT-UN-NABI KHAN & MUZAFFAR IQBAL (2001)[148] Sheep and goats are generally kept together and mainly thrive on grazing for most part of the year. The common flock size is approximately 25 animals, except Karakuls. The migration of sheep and goat flocks from lowlands to highlands starts during the early summer, where they stay till the end of summer season and are brought back to the lowlands in autumn. The young stock and adult sheep and goats are kept in separate flocks and the rams/bucks are not allowed with the adult females during this period. The females are exposed to breeding males during the months of October and November. The rams and bucks are kept in small numbers and one male has to cover about 100 females, however, under the better breeding management conditions one ram is kept for 20-30 ewes. During winter and under severe weather conditions, sheep and goats are provided shelter and are offered concentrates, roughages, hay, straw and tree leaves of various types. Concentrate supplementation is provided for about two months in variable quantities, with preference to weak and advance pregnant animals.

Shearing of sheep is done twice a year and that of goats once a year. Males not kept for breeding are castrated before attaining 12 months age. Mutton from sheep is liked more as compared to goats. For this reason, fattening of young lambs is practiced in Afghanistan, however, at the domestic level only.

Nomads, contribute significantly in the production of sheep and goats for Afghanistan. War seems to impose a little influence on the nomads. It appears that nomads have maintained their flock size, however, the war has posed certain limitations on the grazing opportunities for their livestock. The nomads are successfully maintaining high fertility and low mortality in their flocks. Some of them are making use of anthelmintic and vaccination also.

Karakul sheep have received special attention due to Karakul pelts. The Karakul lambs not kept for breeding are slaughtered within 24 to 36 hours after their births for obtaining the Karakul pelts. It is estimated that the population of Karakul sheep has been restored after the war, however the production of pelts has been affected adversely. The magnitude of decline in the pelt production and around 50 percent due to non-existence of dealers. After meeting the domestic demand of the pelts, the additional Karakul sheep are being bred for mutton and wool production, like other sheep.

[148] Ulfat-un-Nabi Khan & Muzaffar Iqbal (2001) ROLE AND THE SIZE OF LIVESTOCK SECTOR IN AFGHANISTAN A Study Commissioned by The World Bank, Islamabad http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.202.5064&rep=rep1&type=pdf

There are two types of native sheep breeds found in Afghanistan, Fat-tailed and Fat-rumped. The Fat-tailed breeds include Baluchi, Gadai or Gadik (Panjsher Gadik and Wakhan Gadik), Ghiljai or Ghilzai, Hazaragi, Kandahari or Qandahari, and Karakul. The Fat-rumped breeds comprise Afghan Arabi and Turki.

5.1.3.3 Camels

In 2017 about 172, 000 camels were existing in Afghanistan:

- ~ 22,000 camel cows:
    - Camel cows that have calved at least once and are used for milk production
    - ~ 149,000 were females & male camels as well as growing camels

The majority of the camel are for transportation and farm power but also for producing milk and providing meet.

According to MUSTAFA ZAFAR (2007)[149] the majority of camels are of the one-humped dromedary type, which can carry loads up to 140 Kg in the mountains and 180 Kg in the plains. They are mainly kept and used by Kuchis, but also rented out to sedentary farmers. This type of camels is keeping in places which have temperate winter and hot summer. [….] The dromedary camels have two types- riding camels or saddle-camels and burden-camels. The riding camels can carry one person and 50 kg load easily and traveling through 10-15 Km per hour. The selection of camels for breeding, feeding and management in generally are following traditionally and need especially research and studying about their breed's characterization and genetic potentials.

5.1.3.4 Horses, Mules and Asses

In 2017 about 175, 000 camels and about 24,000 Mules and Asses were existing in Afghanistan:

Horses, mules and asses are for transportation, hauling agricultural products to market but also conveying of farmyard manure, soil and for other purposes.

5.1.3.5 Poultry

In 2017 about 13,573,000 Poultry birds were existing in Afghanistan. Currently poultry cannot be divided into

- Chickens
    - Broiler chickens grown for producing meat
    - Layer chickens for producing eggs, where manure is managed in dry systems (e.g., high-rise houses)
    - Layer chickens for producing eggs, where manure is managed in wet systems (e.g., lagoons)
    - Chickens under free-range conditions for egg or meat production
- Turkeys
    - Breeding turkeys in confinement systems
    - Turkeys grown for producing meat in confinement systems
    - Turkeys under free-range conditions for meat production

[149] http://www.fao.org/tempref/docrep/fao/010/a1250e/annexes/CountryReports/Afghanistan.pdf

- Ducks
  - Breeding ducks
  - Ducks grown for producing meat,
- Geese
  - Breeding ducks
  - Ducks grown for producing meat.

Poultry birds are kept under rural poultry production system. Several NGOs are propagating poultry production in Afghanistan and using poultry birds as an instrument for income generation projects.

In Afghanistan there are four local breeds of chicken such as Kulangi, Sabzwari, Pusti and Khasaki.

Poultry and ducks are in large majority raised as backyard fowls with low productivity levels.

5.1.4 Cultivation

Over the years, Afghanistan crop production has fluctuated due to many factors which are mentioned above (chapter 5.1.2). Agricultural products (including carpets and rugs) represent the about 80% of total licit exports (official statistics do not account for smuggled products and transit trade, in particular for opium exports).

The variety of the country's crops corresponds to its topography:

- The areas around Kandahar, Herat, and the broad Kabul plain yield fruits of many kinds.
- The northern regions from Takhar to Badghis and Herat and Helmand provinces produce cotton.
- In Paktia and Nangarhar provinces corn is grown extensively.
- In Kunduz, Baghlan, and Laghman provinces rice is mainly grown.
- Wheat is common to several regions, and makes up 80% of all grain production.
- Nuts, fruit, dried fruits including pistachios, almonds, grapes, melons, apricots, cherries, figs, mulberries, and pomegranates are among Afghanistan’s most important exports.

5.2 Enteric fermentation (IPCC category 3.A)

This section describes the estimation of methane emissions resulting from enteric fermentation from livestock. As described in the 2006 IPCC Guidelines (Volume 4, Chapter 10) methane is produced in herbivores (plant eaters) as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream. The amount of methane that is released depends on the type of digestive tract, age, and weight of the animal, and the quality and quantity of the feed consumed. Ruminant livestock are major sources of methane with moderate amounts produced from non-ruminant livestock.

- The main ruminant livestock are cattle, buffalo, goats, sheep, deer and camels.
- Non-ruminant livestock are horses, mules and asses
- Monogastric livestock are swine

Methane is produced by the fermentation of feed within the animal's digestive system. Generally, the higher the feed intake, the higher the methane emission. Although, the extent of methane production may also be affected by the composition of the diet. Feed intake is positively related to animal size, growth rate, and production (e.g., milk production, wool growth, or pregnancy).

To reflect the variation in emission rates among animal species, the population of animals are divided into subgroups, and an emission rate per animal is estimated for each subgroup.

Natural wild ruminants are not considered in the derivation of a country's emission estimate. Emissions should only be considered from animals under domestic management (e.g., farmed deer, elk, and buffalo).

5.2.1 Source category description

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.A.1	**Enteric Fermentation**						
3.A.1.a	Cattle	NA	-	✓	LA 1990, LA 2017, TA	NA	-
3.A.1.a.i	Dairy Cows	NA	-	✓	(yes, see cattle)	NA	-
3.A.1.a.ii	Other Cattle	NA	-	✓	(yes, see cattle)	NA	-
3.A.1.b	Buffalo	NA	-	NO		NA	-
3.A.1.c	Sheep	NA	-	✓	LA 1990, LA 2017, TA	NA	-
3.A.1.d	Goats	NA	-	✓	LA 1990, LA 2017, TA	NA	-
3.A.1.e	Camels	NA	-	✓	LA 1990, LA 2017, TA	NA	-
3.A.1.f	Horses	NA	-	✓	LA 1990, TA	NA	-
3.A.1.g	Mules and Asses	NA	-	✓	LA 1990, TA	NA	-
3.A.1.h	Swine	NA	-	NO		NA	-
3.A.1.j	Other (please specify)	NA	-	NO		NA	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment

In 2017, this source category was responsible for 72% of agricultural methane emissions and for 63% of the total methane emissions estimated for Afghanistan. It represented 51.2% of the total GHG emissions from the agriculture sector and 23.6% of the total GHG emissions in CO_2eq (excluding LULUCF). In the period 1990 – 2017 the CH_4 emissions increased by 106.4% and in the period 2005 – 2017 the CH_4 emissions increased by

31.5% mainly due to increased number of livestock. Cattle are the most significant source of methane because of their high numbers, large size and ruminant digestive system, followed by sheep and goats. An overview of the methane emissions resulting IPCC category 3.A *Enteric Fermentation* is provided in the following figure and tables. The significant drop and rise in the period 1999 – 2002 and 2009/2010 are mainly due to migration of animals to and from neighboring countries during war.

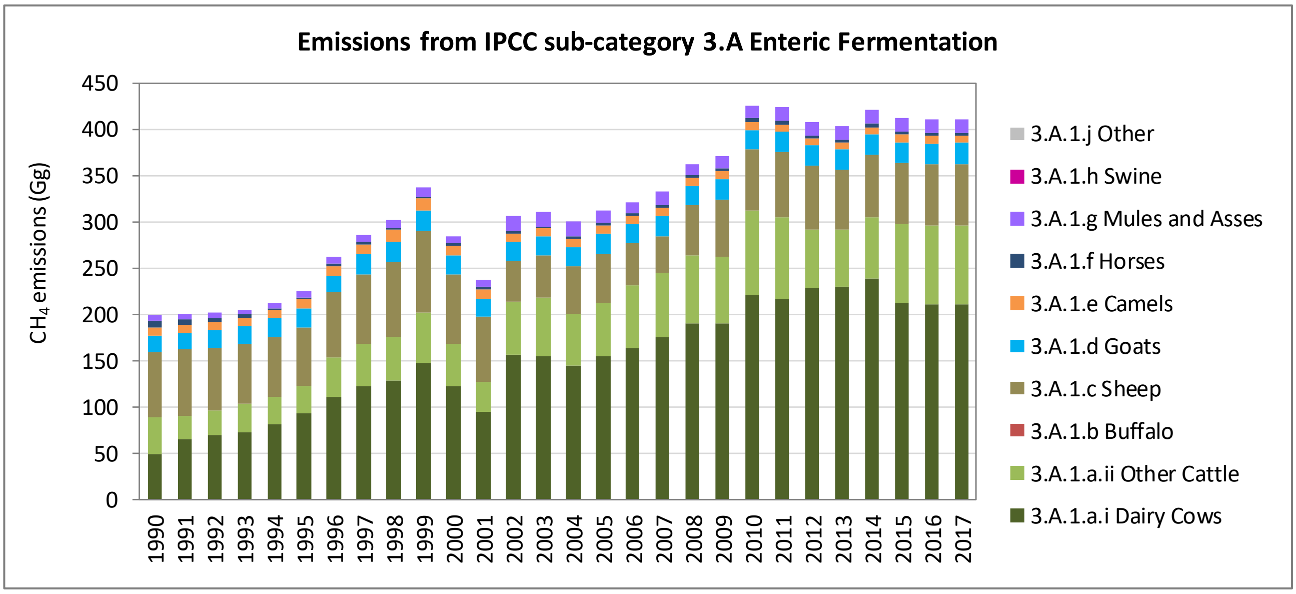


Figure 133 Emissions from IPCC sub-category 3.A Enteric Fermentation

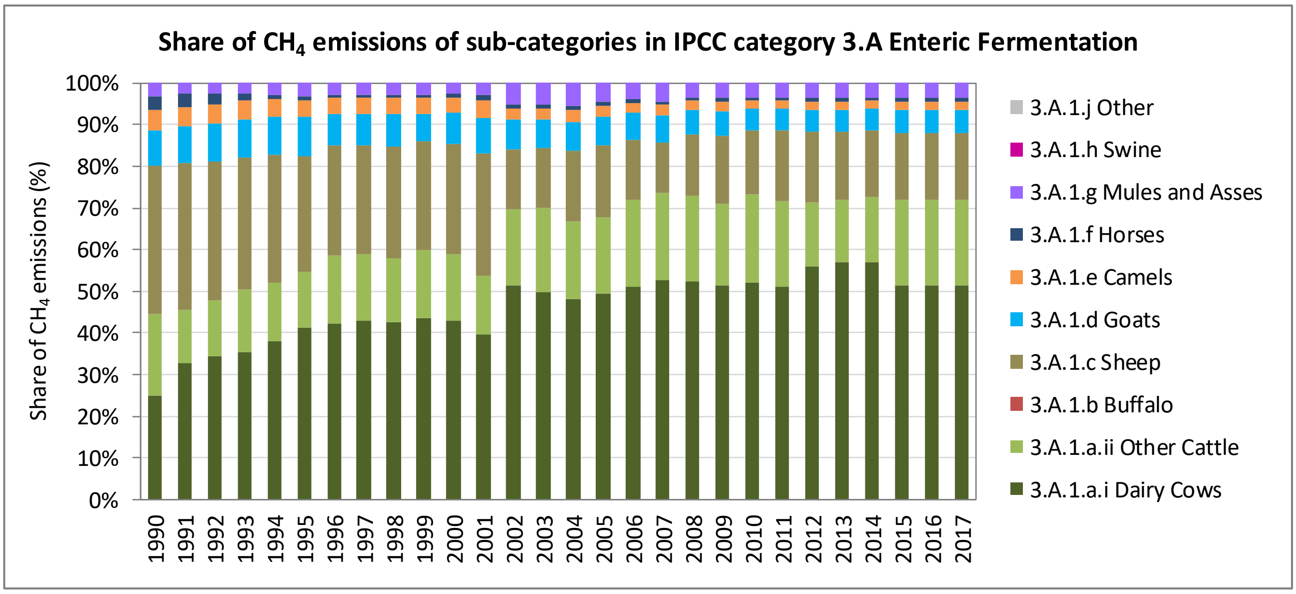


Figure 134 Share of CH_4 emissions of sub-categories in IPCC category 3.A Enteric Fermentation

Table 228 Emissions from IPCC category 3.A Enteric Fermentation by sub-categories

CH_4 emissions	3.A.1	3.A.1.a	3.A.1.a.i	3.A.1.a.ii	3.A.1.b	3.A.1.c	3.A.1.d	3.A.1.e	3.A.1.f	3.A.1.g	3.A.1.h	3.A.1.j
	Enteric Fermentation	Cattle	Dairy Cows	Other Cattle	Buffalo	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Other
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**199.05**	88.78	*49.47*	*39.31*	NO	70.85	16.75	9.89	6.52	6.26	NO	NO
1991	**199.89**	90.69	*65.26*	*25.42*	NO	71.00	17.45	9.20	6.30	5.25	NO	NO
1992	**201.88**	96.39	*69.44*	*26.95*	NO	67.50	18.15	9.20	5.40	5.24	NO	NO
1993	**205.08**	103.20	*72.69*	*30.51*	NO	65.00	18.85	9.20	3.60	5.23	NO	NO
1994	**212.61**	110.83	*80.88*	*29.95*	NO	65.00	19.55	9.20	1.80	6.23	NO	NO
1995	**225.24**	123.03	*92.80*	*30.23*	NO	62.84	21.05	9.25	1.80	7.27	NO	NO
1996	**261.94**	153.33	*110.55*	*42.78*	NO	69.83	19.05	10.17	1.80	7.77	NO	NO
1997	**285.91**	168.07	*122.56*	*45.51*	NO	75.55	21.05	11.13	1.80	8.31	NO	NO
1998	**301.80**	174.62	*128.44*	*46.19*	NO	81.26	23.05	12.19	1.80	8.88	NO	NO
1999	**337.02**	201.79	*146.99*	*54.79*	NO	88.45	22.05	13.36	1.87	9.50	NO	NO
2000	**283.91**	167.52	*121.75*	*45.76*	NO	75.00	21.05	10.30	2.92	7.12	NO	NO
2001	**236.56**	126.94	*93.94*	*33.00*	NO	69.78	19.55	10.30	2.92	7.07	NO	NO
2002	**305.54**	213.41	*156.71*	*56.70*	NO	43.87	21.55	8.05	2.54	16.13	NO	NO
2003	**311.15**	217.58	*155.09*	*62.49*	NO	45.37	21.05	8.33	2.59	16.23	NO	NO
2004	**300.58**	200.71	*145.08*	*55.63*	NO	50.68	21.25	8.74	2.79	16.41	NO	NO
2005	**312.59**	211.90	*154.79*	*57.10*	NO	53.87	21.30	8.65	2.68	14.20	NO	NO
2006	**321.03**	230.67	*164.06*	*66.61*	NO	46.30	21.05	8.00	2.63	12.38	NO	NO
2007	**332.26**	244.26	*175.25*	*69.00*	NO	40.53	21.35	8.56	2.61	14.96	NO	NO
2008	**362.30**	263.74	*190.26*	*73.48*	NO	53.55	21.35	8.42	2.92	12.33	NO	NO
2009	**371.01**	262.82	*190.56*	*72.26*	NO	61.44	21.35	8.74	3.19	13.48	NO	NO

CH_4 emissions	3.A.1	3.A.1.a	3.A.1.a.i	3.A.1.a.ii	3.A.1.b	3.A.1.c	3.A.1.d	3.A.1.e	3.A.1.f	3.A.1.g	3.A.1.h	3.A.1.j
	Enteric Fermentation	**Cattle**	**Dairy Cows**	**Other Cattle**	**Buffalo**	**Sheep**	**Goats**	**Camels**	**Horses**	**Mules and Asses**	**Swine**	**Other**
	Gg	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**
2010	**426.03**	311.73	*221.57*	*90.15*	NO	66.43	21.25	8.79	3.55	14.29	NO	NO
2011	**423.51**	304.07	*216.41*	*87.66*	NO	71.31	22.05	7.91	3.26	14.91	NO	NO
2012	**407.79**	291.47	*228.21*	*63.26*	NO	69.10	21.55	8.00	3.20	14.47	NO	NO
2013	**403.39**	290.89	*230.13*	*60.76*	NO	65.71	21.18	7.82	3.08	14.72	NO	NO
2014	**420.23**	304.83	*238.78*	*66.05*	NO	67.43	22.38	7.87	3.08	14.65	NO	NO
2015	**412.37**	296.86	*212.15*	*84.72*	NO	66.09	23.43	7.82	3.11	15.06	NO	NO
2016	**410.61**	295.39	*211.19*	*84.20*	NO	66.33	23.00	7.84	3.08	14.97	NO	NO
2017	**410.93**	295.47	*211.27*	*84.20*	NO	66.33	23.24	7.84	3.08	14.97	NO	NO
Trend												
1990 - 2017	**106%**	233%	*327%*	*114%*	NA	-6%	39%	-21%	-53%	139%	NA	NA
2005 - 2017	**31%**	39%	*36%*	*47%*	NA	23%	9%	-9%	15%	5%	NA	NA
2016 - 2017	**0%**	0%	*0%*	*0%*	NA	0%	1%	0%	0%	0%	NA	NA

5.2.2 Methodological issues

5.2.2.1 Choice of methods

Step 1: Divide the livestock population into subgroups and characterize each subgroup (as described in Section 10.2. of Volume 4: AFOLU of the 2006 IPCC Guidelines) and presented in chapter 5.2.2.2

Step 2: Estimate emission factors for each subgroup in terms of kilograms of methane per animal per year.

Step 3: Multiply the subgroup emission factors by the subgroup populations to estimate subgroup emission, and sum across the subgroups to estimate total emission.

For estimating the CH_4 emissions from livestock the 2006 IPCC Guidelines approach[150] has been applied:

- Tier 2 approach: cattle

  A more complex approach that requires detailed country-specific data on gross energy intake and methane conversion factors for specific livestock categories. The Tier 2 method should be used if enteric fermentation is a <u>key source category</u> for the animal category that represents a large portion of the country's total emissions.

- Tier 1 approach: for all other livestock categories - sheep, goats, horses, mules and asses.

  A simplified approach that relies on default emission factors drawn from the literature. The Tier 1 method is likely to be suitable for most animal species in countries where enteric fermentation is <u>not a key source category</u>, or where enhanced characterization data are not available.

TIER 1

Equation 10.19: CH_4 emissions from enteric fermentation from a livestock category

$$\boldsymbol{Emissions_{CH4} = Livestock_{\ category} \times \left(\frac{Emission\ Factor_T}{10^6}\right)}$$

Where:

Emissions $_{CH4}$	= CH_4 emissions (Gg CH_4)
Livestock $_{category}$	= number of head of livestock species / category T
Emission factor $_T$	= default emission factor for a defined livestock population (kg CH_4 $head^{-1}$).
T	= species/category of livestock

TIER 2

Equation 10.19: CH_4 emissions from enteric fermentation from a livestock category
with Equation 10.21: TIER 2 - CH_4 emission factors for enteric fermentation from a livestock category

$$\boldsymbol{Emissions_{CH4} = Livestock_{\ category} \times \left(\frac{GE \times \left(\frac{Y_m}{100}\right) \times 365}{55.65}\right)}$$

Where:

Emissions $_{CH4}$	= CH_4 emissions (Gg CH_4)
Livestock $_{category}$	= number of head of livestock species / category T
Emission factor $_T$ = $\left(\frac{GE \times \left(\frac{Y_m}{100}\right) \times 365}{55.65}\right)$	**=** Tier 2 emission factor for a defined livestock population (kg CH_4 $head^{-1}$).
GE	= gross energy intake (MJ $head^{-1}$ day^{-1})
Ym	= methane conversion factor (MCF), per cent of gross energy in feed converted to methane
55.65	= The factor 55.65 (MJ/kg CH_4) is the energy content of methane.
365	= It is assumed that the EFs are being developed for an animal category for an entire year (365

[150] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chap. 10 Emissions from Livestock and Manure Management; sub-chapter 10.2.2 Choice of method

days).

The calculation of the **gross energy intake (GE)** depends on the animal performance and diet data which is the amount of energy (MJ/day) an animal needs for maintenance and for activities such as growth, lactation, and pregnancy. As no country-specific methods are available, energy intake was calculated using the equations listed in Table 10.3. of Section 10.2. of Volume 4: AFOLU of the 2006 IPCC Guidelines (p. 10.15) and presented in the following table.

Table 229 Summary of the equations used to estimate daily gross energy intake for cattle

Metabolic functions and other estimates	2006 IPCC GL, Vol. 4, Chap. 10	Equations for cattle and buffalo
Net energy for Maintenance (NE_m) is the net energy required for maintenance, which is the amount of energy needed to keep the animal in equilibrium where body energy is neither gained nor lost	Equation 10.3 (page 10.16)	$NE_m = Cf_i \times (Weight)^{0.75}$
Net energy for Activity (NE_a) is the net energy for activity, or the energy needed for animals to obtain their food, water and shelter. It is based on its feeding situation rather than characteristics of the feed itself.	Equation 10.4 (page 10.17)	$NE_a = C_a \times NE_m$
Net energy for Growth (NE_g) is the net energy needed for growth (i.e., weight gain)	Equation 10.6 (page 10.17)	$NE_g = 22.02 \times \left(\frac{BW}{C \times MW}\right)^{0.75} \times WG^{1.097}$
Net energy for Lactation (NE_l) is the net energy for lactation. For cattle and buffalo the net energy for lactation is expressed as a function of the amount of milk produced and its fat content expressed as a percentage	Equation 10.8 (page 10.18)	$NE_l = milk \times (1.47 + 0.4 \times Fat$
Net energy for Draft Power (NE_{work}) is the net energy for work. It is used to estimate the energy required for draft power for cattle and buffalo.	Equation 10.11 (page 10.19)	$NE_{work} = 0.10 \times NE_m \times hours$
Net energy for Wool Production (NE_{wool}) is the average daily net energy required for sheep to produce a year of wool.	Equation 10.12 (page 10.19)	NA - not applicable
Net energy for Pregnancy (NE_p) is the energy required for pregnancy. For cattle and buffalo, the total energy requirement for pregnancy for a 281-day gestation period averaged over an entire year is calculated as 10% of NE_m.	Equation 10.13 (page 10.20)	$NE_p = C_{pregnancy} \times NE_m$

Metabolic functions and other estimates	2006 IPCC GL, Vol. 4, Chap. 10	Equations for cattle and buffalo
Ratio of net energy available in diet for maintenance to digestible energy consumed (REM)	Equation 10.14 (page 10.20)	$REM = \left[1.123 - (4.092 \times 10^{-3} \times DE\%) + [1.126 \times 10^{-5} \times (DE\%)^2] - \left(\frac{25.4}{DE\%}\right)\right]$
Ratio of net energy available for growth in a diet to digestible energy consumed (REG)	Equation 10.15 (page 10.21)	$REG = \left[1.164 - (5.160 \times 10^{-3} DE\%) + [1.308 \times 10^{-5} \times (DE\%)^2] - \left(\frac{37.4}{DE\%}\right)\right]$
Gross Energy (GE)	Equation 10.16 (page 10.21)	$GE = \left(\frac{\left(\frac{NE_m + NE_a + NE_l + NE_{work} + NE_p}{REM}\right) + \left(\frac{NE_g}{REG}\right)}{\frac{DE\%}{100}}\right)$

Where

NE_m = net energy required by the animal for maintenance (MJ day^{-1})

Cf_i = a coefficient which varies for each animal category (MJ day^{-1} kg^{-1})
with default from Table 10.4 of Section 10.2. of Volume 4: AFOLU of the 2006 IPCC Guidelines (p. 10.15)

Weight = live-weight of animal (kg)

C_a = coefficient corresponding to animal's feeding situation
with default from Table 10.5 of Section 10.2. of Volume 4: AFOLU of the 2006 IPCC Guidelines (p. 10.16)

BW = the average live body weight (BW) of the animals in the population (kg)

C = a coefficient with a value of 0.8 for females, 1.0 for castrates and 1.2 for bulls

MW = the mature live body weight of an adult animal in moderate body condition (kg)

WG = the average daily weight gain of the animals in the population (kg day^{-1})

Milk = amount of milk produced (kg of milk day^{-1})

Fat = fat content of milk (%) by weight

Hours = number of hours of work per day

$C_{pregnancy}$ = pregnancy coefficient
with default from Table 10.7 of Section 10.2. of Volume 4: AFOLU of the 2006 IPCC Guidelines (p. 10.20)

DE% = digestible energy expressed as a percentage of gross energy

Finally, the total emissions from the species/category of livestock was estimated applying the following equation[151]:

Equation 10.20: Total emissions from livestock enteric fermentation

$$\boldsymbol{Emissions_{CH4\ enteric} = \sum_i emissions_i}$$

Where:

Emissions $_{CH4\ enteric}$ = total CH_4 emissions from Enteric Fermentation (Gg CH_4)

Emission $_i$ = emissions for the i^{th} livestock categories and subcategories.

[151] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chap. 10 Emissions from Livestock and Manure Management; sub-chap. 10.3.2 Choice of emission factor

5.2.2.2 Choice of activity data

As described in Chapter 0 above, the agricultural data used and presented in this inventory are taken from national and international sources:

- Afghanistan National Livestock Census[127]
- Afghanistan Statistical yearbook[128]
- CountrySTAT[129]
- FAO agricultural data base[130]

Additional national publications such as ALCS (different years) were used to cross-check the used statistics. The original data provider for the national and international database is the Ministry of Agriculture Irrigation and Livestock (MAIL).

Cattle

In 2017 there were about 5,234,400 cattle[152], of which about 73% were dairy- cattle / cows. The number of cattle increased by 211% in the period 1990 – 2017 and by 34% in the period 2005 – 2017. Compared to the non-dairy cattle (calves, bulls, bovines) which increased by 109 % the dairy cattle increased significantly by 344% in the period 1990 - 2017. Between 2005 and 2017 the number of dairy-cattle increased by 38% and the number of non-dairy cattle increased by 47%.

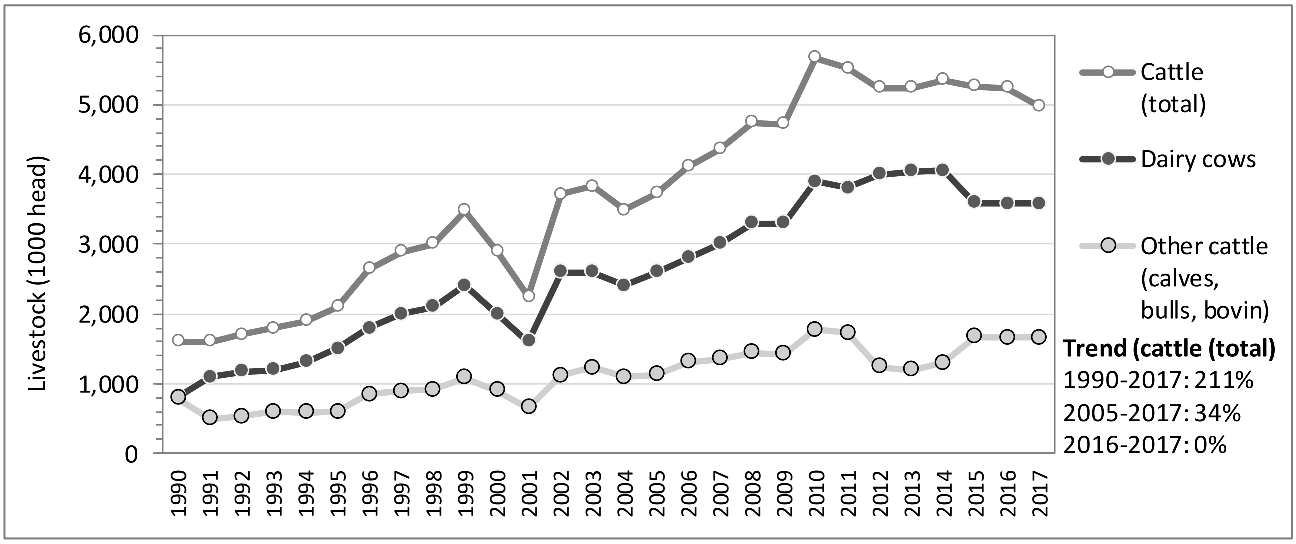


Figure 135 Cattle - dairy and non-dairy (calves, bulls, bovines) population and its trend 1990–2017

Based on expert judgement the non-dairy cattle are split into two groups with a share of

- 80% - Other non-dairy cattle: Suckling cows, calves and young cattle, breeding and fattening heifers;
- 20% - Bulls & Oxen.

Due to a technical mistake the emissions for 2017 are estimated based on livestock number of 2016. 4,977,000 cattle

Table 230 Cattle and Buffalo: domestic livestock population and its trend 1990–2017

	Population size [1000 heads] * Livestock category									
	Cattle (total)		***Dairy cows***		**Other non-dairy cattle (calves, bovine)**		**Bulls & oxen**		**Buffalo**	
1990	1,600	FAO estimate	807	FAO estimate	793	FAO estimate / Expert judgement	NO	Expert judgement	NO	FAO estimate
1991	1,600		1,100		500		NO		NO	
1992	1,700		1,170		530		NO		NO	
1993	1,800		1,200		600		NO		NO	
1994	1,900		1,311		589		NO		NO	
1995	2,095		1,500		595		NO		NO	
1996	2,641		1,800		841		NO		NO	
1997	2,895	NSIA - Statistical YB	2,000		895		NO		NO	
1998	3,008		2,100		908		NO		NO	
1999	3,478		2,400		1,078		NO		NO	
2000	2,900		2,000		900		NO		NO	
2001	2,249		1,600		649		NO		NO	
2002	3,715	LC	2,600		1,115		NO		NO	LC
2003	3,829	NSIA - Statistical yearbooks	2,600		1,229		NO		NO	FAO (official estimates)
2004	3,494		2,400		1,094		NO		NO	
2005	3,723		2,600		1,123		NO		NO	
2006	4,110		2,800		1,310		NO		NO	
2007	4,357		3,000		1,357		NO		NO	
2008	4,745		3,300		1,445		NO		NO	NSIA - Statistical YB
2009	4,721		3,300		1,421		NO		NO	
2010	5,673		3,900		1,773		NO		NO	
2011	5,524		3,800		1,724		NO		NO	
2012	5,244		4,000		1,244		NO		NO	
2013	5,235		4,040		1,195		NO		NO	
2014	5,349		4,050		1,299		NO		NO	
2015	5,261		3,595		1,666		NO		NO	
2016	5,234		3,579		1,656		NO		NO	
2017	5,234 p		3,579 p		1,656 p		NO		NO	
Trend										
1990 - 2017	*207%*		*344%*		*109%*		*NA*		*NA*	
2005 - 2017	*41%*		*38%*		*47%*		*NA*		*NA*	
2016 - 2017	*0%*		*0%*		*0%*		*NA*		*NA*	

Remark: p – preliminary (value of 2016); LC – Afghanistan National Livestock Census 2002-2003, FAO, OSRO/AFG/212/AFG

Sheep and goats

The number of sheep decreased by 2% in the period 1990 – 2017 but increased by 29% in the period 2005 – 2017. Compared to the 'other sheep' (lambs, rams, young sheep) which decreased by 14% the mature eves increased by 1% in the period 1990 - 2017. Between 2005 and 2017 the number of mature eves increased by 32% and the number of 'other sheep' (lambs, rams, young sheep) increased by 14%.

The number of goats increased by 127% in the period 1990 – 2017 and by 9% in the period 2005 – 2017. Compared to the 'other goats' (lambs, rams, young goats) which increased only by 97% the mature eves increased by 139% in the period 1990 - 2017. Between 2005 and 2017 the number of mature eves increased by 17% and the number of 'other goats' increased by 2%.

The increase of sheep and goats' number is mainly due to improved forage production and sheep reproduction programs, etc. The main products are milk and cheese as well as skin and wool and finally meat.

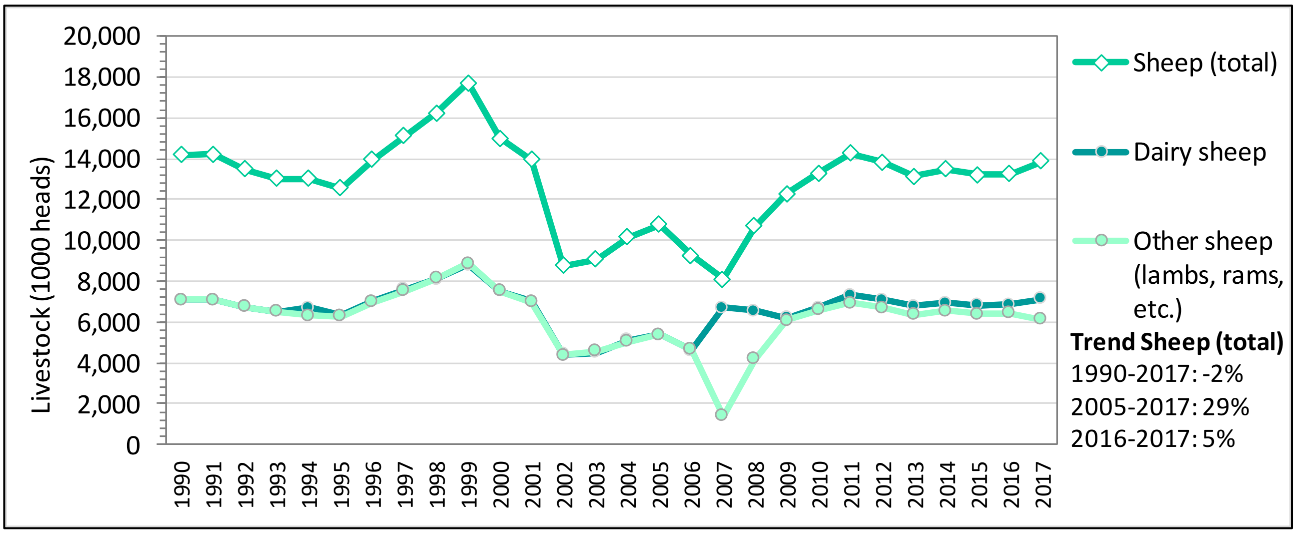


Figure 136 **Sheep - dairy and non-dairy (lambs, rams, young sheep) population and its trend 1990–2017**

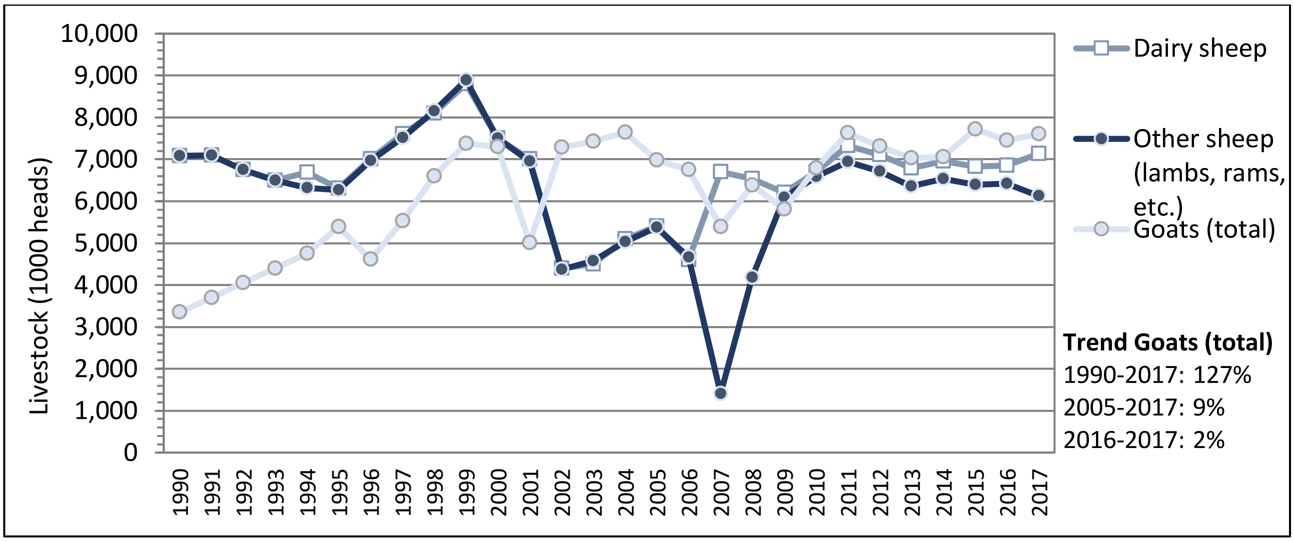


Figure 137 **Goats - dairy and non-dairy (lambs, rams, young goats) population and its trend 1990–2017**

Table 231 **Sheep and goats: domestic livestock population and its trend 1990–2017**

	Population size [1000 heads] * Livestock category											
	Sheep (total)		***Dairy sheep***		***Other sheep (non-dairy)***		**Goats (total)**		***Dairy goats***		***Other goats (non-dairy)***	
1990	14,170	FAO estimate	7,085	FAO estimate	7,085	FAO estimate	3,350	FAO estimate	1,340	FAO estimate	2,010	FAO estimate
1991	14,200		7,100		7,100		3,700		1,480		2,220	
1992	13,500		6,750		6,750		4,050		1,620		2,430	
1993	13,000		6,500		6,500		4,400		1,760		2,640	
1994	13,000		6,687		6,313		4,750		1,900		2,850	

	Population size [1000 heads] * Livestock category							
	Sheep (total)	Source	***Dairy sheep***	***Other sheep (non-dairy)***	**Goats (total)**	Source	***Dairy goats***	***Other goats (non-dairy)***
1995	12,568		6,300	6,268	5,389		2,200	3,189
1996	13,965		7,000	6,965	4,609		1,800	2,809
1997	15,110		7,600	7,510	5,531		2,200	3,331
1998	16,252		8,100	8,152	6,599		2,600	3,999
1999	17,690		8,800	8,890	7,373		2,400	4,973
2000	15,000		7,500	7,500	7,300		2,200	5,100
2001	13,955		7,000	6,955	5,003		1,900	3,103
2002	8,773	LC	4,400	4,373	7,281	LC	2,300	4,981
2003	9,074	FAO (official estimates)	4,500	4,574	7,425	FAO (official estimates)	2,200	5,225
2004	10,136		5,100	5,036	7,648		2,240	5,408
2005	10,773		5,400	5,373	6,977		2,250	4,727
2006	9,259		4,600	4,659	6,746		2,200	4,546
2007	8,105		6,700	1,405	5,387		2,260	3,127
2008	10,710		6,530	4,180	6,386		2,260	4,126
2009	12,287		6,200	6,087	5,810		2,260	3,550
2010	13,286		6,700	6,586	6,789		2,240	4,549
2011	14,262	NSIA - Statistical yearbooks	7,319	6,943	7,635	NSIA - Statistical yearbooks	2,400	5,235
2012	13,820		7,109	6,711	7,311		2,300	5,011
2013	13,141		6,785	6,356	7,037		2,226	4,811
2014	13,485		6,952	6,533	7,059		2,466	4,593
2015	13,218		6,825	6,393	7,723		2,675	5,048
2016	13,265		6,849	6,416	7,448		2,590	4,858
2017	13,866		7,139	6,126	7,598		2,637	4,811
Trend								
1990 - 2017	*-2%*		*1%*	*-14%*	*127%*		*97%*	*139%*
2005 - 2017	*29%*		*32%*	*14%*	*9%*		*17%*	*2%*
2016 - 2017	*5%*		*4%*	*-5%*	*2%*		*2%*	*-1%*
Remark: LC – Afghanistan National Livestock Census 2002-2003, FAO, OSRO/AFG/212/AFG								

Camels

The number of camels decreased by 20% in the period 1990 – 2017 and by 9% in the period 2005 – 2017. Compared to the non-dairy camels (calves, bulls, young camels) which decreased by 23% the dairy camels remain stable in the period 1990 - 2017. Between 2005 and 2017 the number of dairy-camels decreased by 14% and the number of non-dairy camels decreased by 9%. please add here more information.

The majority of the camel are for transportation and farm power but also for producing milk and providing meet.

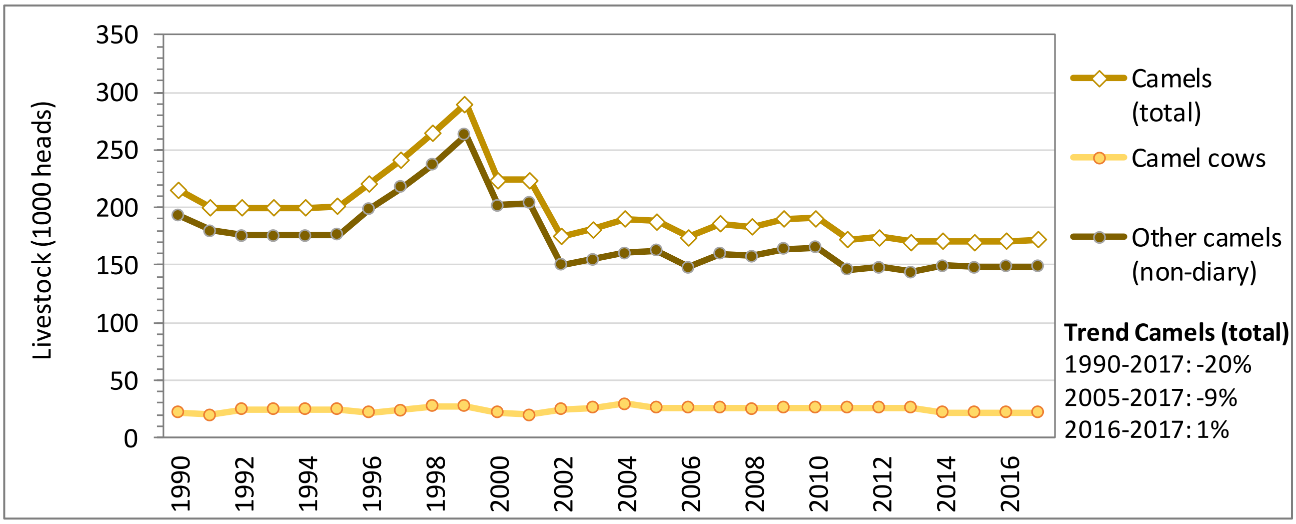


Figure 138 **Camels population and its trend 1990–2017**

Horses, Mules and Asses

The number of **Horses** decreased significantly by 52% in the period 1990 – 2017 and increased by 17% in the period 2005 – 2017. The number of **Mules and Asses** decreased by 8% in the period 1990 – 2017 and decreased by 17% in the period 2005 – 2017.

Horses, mules and asses are for transportation, hauling agricultural products to market but also conveying of farmyard manure, soil and for other purposes.

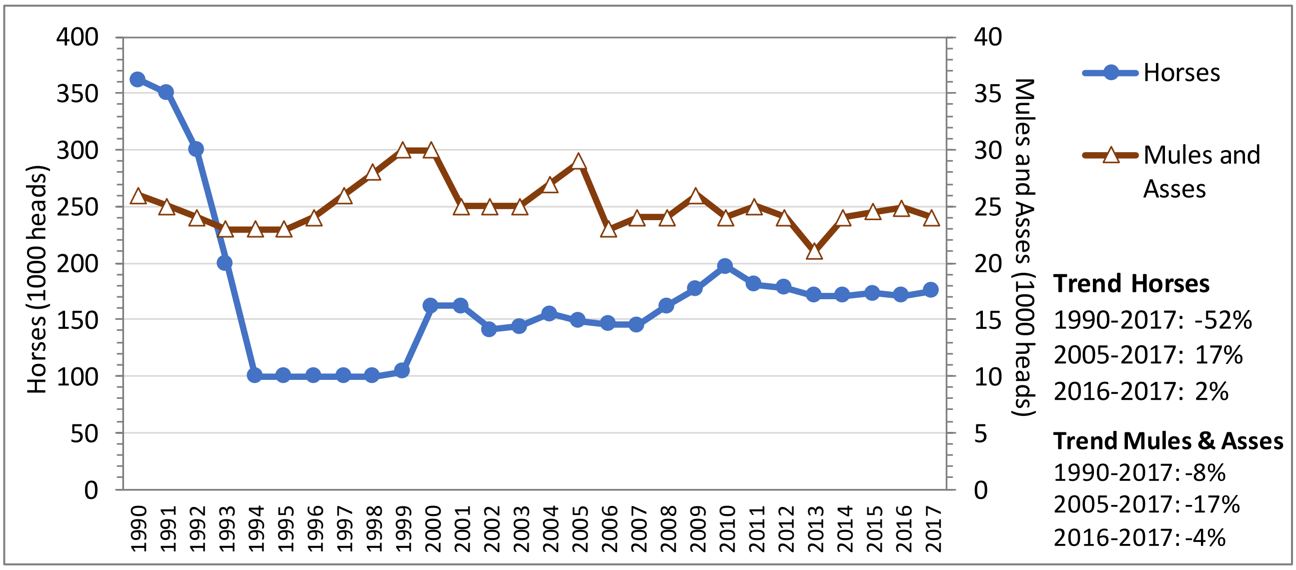


Figure 139 **Horses, mules and asses: population and its trend 1990–2017**

Poultry

The number of **Poultry birds** increased significantly by 52% in the period 1990 – 2017 and decreased by 6% in the period 2005 – 2017. Currently poultry cannot be divided into in laying hens, broilers, turkeys and Other poultries.

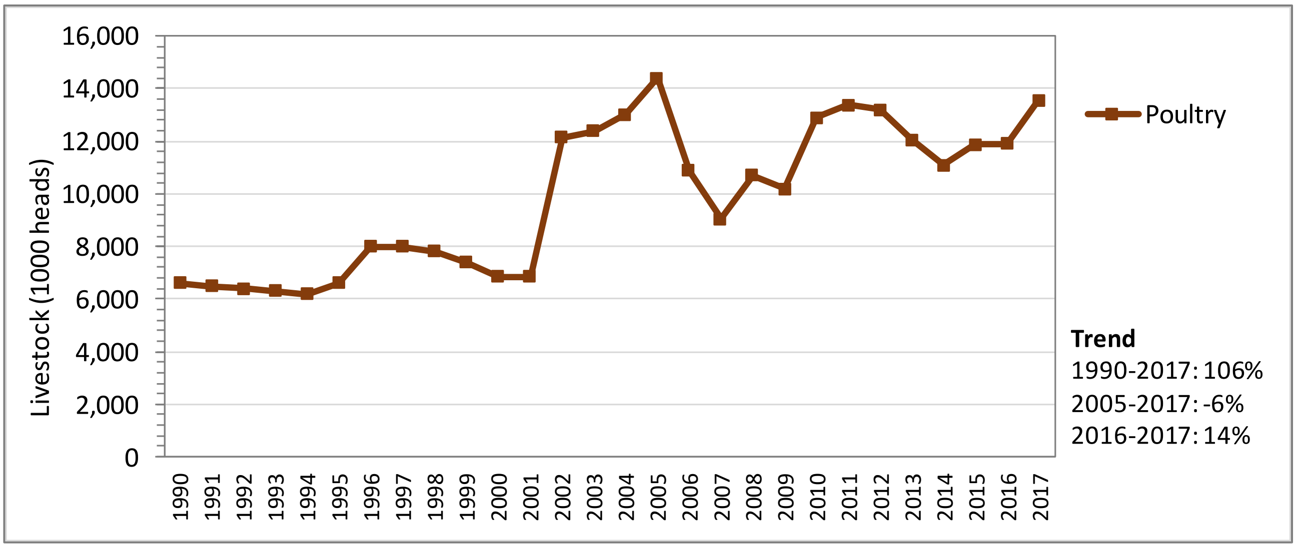


Figure 140 **Poultry birds' population and its trend 1990–2017**

Table 232 **Camels, horses, mules and asses, poultry: domestic livestock population and its trend**

	Population size [1000 heads] * Livestock category											
	Camels (total)		***Camel cows***		***Other camels (non-dairy)***		**Horses**		***Mules and Asses***		***Poultry***	
1990	215	FAO estimate	22	FAO estimate	193	FAO estimate	362	FAO estimate	26	FAO estimate	6,600	FAO estimate
1991	200		20		180		350		25		6,500	
1992	200		25		175		300		24		6,400	
1993	200		25		175		200		23		6,300	
1994	200		25		175		100		23		6,200	
1995	201		25		176		100		23		6,602	
1996	221		22		199		100		24		8,000	
1997	242		24		218		100		26		8,000	
1998	265		27		238		100		28		7,828	
1999	290		27		263		104		30		7,400	
2000	224		22		202		162		30		6,856	
2001	224		20		204		162		25		6,844	
2002	175	LC	25		150		141	LC	25		12,156	
2003	181	FAO (official estimates)	26		155		144	FAO (official estimates)	25		12,402	
2004	190		30		160		155		27		13,022	
2005	188		26		162		149		29		14,414	
2006	174		26		148		146		23		10,880	
2007	186		26		160		145		24		9,035	
2008	183	NSIA -	25		158		162		24		10,689	
2009	190		26		164		177		26		10,193	
2010	191		26		165		197		24		12,888	

	Population size [1000 heads] * Livestock category											
	Camels (total)		***Camel cows***		***Other camels (non-dairy)***		**Horses**		***Mules and Asses***		***Poultry***	
2011	172		26		146		181	NSIA - Statistical yearbooks	25	FAO estimate	13,378	FAO estimate
2012	174		26		148		178		24		13,212	
2013	170		26		144		171		21		12,053	
2014	171		22		149		171		24		11,098	
2015	170		22		148		173		25		11,863	
2016	171		22		149		171		25		11,899	
2017	172		22		149		175		24		13,573	
Trend												
1990 - 2017	*-20%*		*0%*		*-23%*		*-52%*		*-8%*		*106%*	
2005 - 2017	*-9%*		*-14%*		*-9%*		*17%*		*-17%*		*-6%*	
2016 - 2017	*1%*		*1%*		*0%*		*2%*		*-4%*		*14%*	
Remark: LC – Afghanistan National Livestock Census 2002-2003, FAO, OSRO/AFG/212/AFG												

5.2.2.3 Choice of emission factors

For estimating the CH_4 emissions from cattle the 2006 IPCC Guidelines Tier 2 approach[153] has been applied. For all other livestock categories (sheep, goats, horses, mules and asses), the 2006 IPCC Guidelines Tier 1 was used.

Emission factor for cattle

CH_4 emissions from enteric fermentation – cattle (sum of dairy and non-dairy cattle) are a key source due to the contribution to total greenhouse gas emissions in Afghanistan and also due to its contribution to the total inventory's trend. In the year 2017, emissions from enteric fermentation – cattle contributed 24% to total greenhouse gas emissions in Afghanistan.

Country specific emission factors were used for dairy cattle, bulls & oxen and 'other non-dairy cattle'. They were calculated from the specific gross energy intake and the methane conversion rate.

Equation 10.21: TIER 2 - CH_4 emission factors for enteric fermentation from a livestock category

$$\boldsymbol{Emission\ factor_{CH4}} = \left(\frac{\boldsymbol{GE} \times \left(\frac{\boldsymbol{Y_m}}{\boldsymbol{100}}\right) \times \boldsymbol{365}}{\boldsymbol{55.65}} \right)$$

Where:

- Emission factor $_{CH4}$ = CH_4 emission factor (kg CH_4 head^{-1})
- GE = gross energy intake (MJ head^{-1} day^{-1})
- Ym = methane conversion factor (MCF), per cent of gross energy in feed converted to methane
- 55.65 = The factor 55.65 (MJ/kg CH_4) is the energy content of methane.
- 365 = The EF equation assumes that the EFs are being developed for an animal category for an entire year (365 days).

[153] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10 Emissions from Livestock and Manure Management - sub-chapter 10.3.2 Choice of EF

1. Obtaining the Methane conversion factor (Ym)

The extent to which feed energy is converted to CH_4 depends on several interacting feed and animal factors. As country-specific information was not available the IPCC default CH_4 conversion factors (YM) was used.

Table 233 Cattle CH_4 conversion factors (Ym)

Livestock category	Ym
Dairy Cows (Cattle and Buffalo) and their young	6.5%
Other Cattle and Buffaloes that are primarily fed low quality crop residues and by-products	6.5%
Other Cattle or Buffalo – grazing	6.5%
Source: 2006 IPCC Guidelines, Volume 4, Chapter 10: Table 10.12 Cattle / Buffalo CH_4 conversion factors (Ym); page 10.30	

Equation 10.16: Gross energy for cattle/buffalo and sheep

$$GE = \left(\frac{\left(\frac{NE_m + NE_a + NE_l + NE_{work} + NE_p}{REM} \right) + \left(\frac{NE_g}{REG} \right)}{\frac{DE\%}{100}} \right)$$

Where:

GE = gross energy per day (MJ)

NE_m = net energy required by the animal for maintenance per day (Equation 10.3) (MJ)

NE_a = net energy for animal activity per day (Equations 10.4 and 10.5) (MJ)

NE_l = net energy for lactation per day (Equations 10.8, 10.9, and 10.10) (MJ)

NE_{work} = net energy for work per day (Equation 10.11) (MJ)

NE_p = net energy required for pregnancy (Equation 10.13) (MJ)

REM = ratio of net energy available in a diet for maintenance to digestible energy consumed (Equation 10.14)

NE_g = net energy needed for growth (Equations 10.6 and 10.7) (MJ)

REG = ratio of net energy available for growth in a diet to digestible energy consumed (Equation 10.15)

DE% = digestible energy expressed as a percentage of gross energy

Herat, Afghanistan ©Mohammad Monib Noori

Table 234 Exemplary calculation of methane emissions for cattle for 2017 applying TIER 2 approach for 3.B. Manure Management

Parameter	Parameter description	Unit	Formula (as used in Excel)	Source	Source / Remarks	Cows	Non-dairy cattle	Bulls , oxen
L	Livestock (# of animals)		-	Total cattle: NSIA; Cows – non-dairy cattle: FAO; Split non-dairy – oxen/bulls: Expert judgement		3,578,531	1,324,695	331,174
W (=MW)	Live Weight	Kg	-	First Draft Country Report on the Status and Perspectives of the Animal Genetic Resources Development and Conservation in Afghanistan[154]		233.75	200	275
BW	Live Body Weight	Kg	0.266xW^0.79	Equation 7 Chap 4.2.4, Rev. 1996 IPCC GL; Ref. Manual; p. 4.19		19.78	17.49	22.49
WG	Average Daily Weight Gain	kg/day	-	-		NA	NA	NA
AMiY	Annual Milk Yield	kg/cow/year	-	FAOstat	Livestock Processed *http://www.fao.org/faostat/en/#data/QP*	524	NA	NA
DMiY	Daily Milk Yield	kg/cow/day	AMiY/365.25	Chap. 10.2.2, Vol. 4, 2006 IPCC Guidelines; p. 10.13		**1.43**	NA	NA
Fat	Fat Content of Milk	%	-	Expert Judgment based on FAO_AFG: Zafar (2006)		3.8%	NA	NA
DE	Digestible Energy	%	-	Table 10.2 Chap. 10, Vol. 4, 2006 IPCC Guidelines; p. 10.14	Pasture fed animals; Animals fed – low quality forage	**55%**	**55%**	**55%**
CF_i	Coefficients for calculating net energy for maintenance	MJ/day/kg		Table 10.4 Chap. 10, Vol. 4, 2006 IPCC Guidelines; p. 10.16		0.386	0.322	0.370
NEm	Net Energy for Maintenance	MJ/day	CFi xW^0.75	Equation 10.3 Chap. 10, Vol. 4, 2006 IPCC Guidelines, p. 10.15		23.08	20.53	26.07
C_a	Activity coefficients corresponding to animal's feeding situation	-	(0.36+0.17)/2	(1) Animals are confined in areas with sufficient forage requiring modest energy expense to acquire feed. (2) Animals graze in open range land or hilly terrain and expend significant energy to acquire feed.		0.265	0.265	0.265
NEa	Net Energy for Activity	MJ/day	(C_a/2)xNEm	Equation 10.4 Chap. 10, Vol. 4, 2006 IPCC Guidelines, p. 10.16		6.12	9.13	6.91
NEg	Net Energy for Growth	MJ/day	22.02x(BW/0.8xMW)^0.75x (WG)^1.097	Equation 10.6 Chap. 10, Vol. 4, 2006 IPCC Guidelines, p. 10.17		0.00	0.00	NO
NEl	Net Energy for Lactation	MJ/day	DMiYx(1.47+0.4xFat)	Equation 10.8		4.29	4.47	NA

[154] FAO (2008): Available on 05.04.2019 at: http://www.fao.org/tempref/docrep/fao/010/a1250e/annexes/CountryReports/Afghanistan.pdf

Parameter	Parameter description	Unit	Formula (as used in Excel)	Source	Source / Remarks	Cows	Non-dairy cattle	Bulls , oxen
				Chap. 10, Vol. 4, 2006 IPCC Guidelines, p. 10.18				
NEw	Net Energy for Draft Power (Work)	MJ/day	0.10xNEmxhours worked per day	Equation 10.11 Chap. 10, Vol. 4, 2006 IPCC Guidelines, p. 10.19	Expert judgment: Bulls: 2h per day Non-dairy: 1h per day	NO	2.05	5.21
NEp	Net Energy for Pregnancy	MJ/day	0.10xNEm	Equation 10.13 Chap. 10, Vol. 4, 2006 IPCC Guidelines, p. 10.20		2.31	2.31	NA
REM	Ratio of Net Energy in a Diet for Maintenance to Digestible Energy Consumed	#	1.123-(4.092x10^-3xDE)+(1.126x10^-5xDE^2)-(25.4/DE)	Equation 10.14 Chap. 10, Vol. 4, 2006 IPCC Guidelines, p. 10.20		0.47	0.47	0.47
REG	Ratio of Net Energy Available for Growth in a Diet to Digestible Energy Consumed	#	1.164-(5.160x10^-3xDE)+(1.308x10^-5xDE^2)-(37.4/DE)	Equation 10.15 Chap. 10, Vol. 4, 2006 IPCC Guidelines, p. 10.21		0.24	0.24	0.24
GE	Gross Energy Intake (average)	MJ/day	{[(NEm+NEa+NEl+NEw+NEp)/REM]+[NEg/REG]}/(DE/100)	Equation 10.16 Chap. 10, Vol. 4, 2006 IPCC Guidelines, p. 10.21		**138.39**	**109.55**	**157.75**
Ym	CH_4 conversion rate (average)	%		Table 10.12 Chap. 10, Vol. 4, 2006 IPCC Guidelines, p. 10.28		**6.50%**	**6.50%**	**6.50%**
EF - CH_4	**Emission Factor (EF) - CH_4**	**kg CH_4/head/year**	(GExYmx365)/55.65	**Equation 10.21** Chap. 10, Vol. 4, 2006 IPCC Guidelines, p. 10.28		**59.04**	**46.74**	**67.30**
CH_4 Emi	**CH_4 Emissions**	**Gg CH_4**	L x EF_{CH4} x 10^-6	**Equation 10.19** Chap. 10, Vol. 4, 2006 IPCC Guidelines, p. 10.28		**211.27**	**61.91**	**22.29**
M	*Method*	-	-	-		*Tier 2*	*Tier 2*	*Tier 2*
EF used	*EF used*	-	-	-		*Country specific (CS)*	*Country specific (CS)*	*Country specific (CS)*

The default emission factors methane (CH_4) were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 235 Emission factors for Tier 1 for IPCC sub-category 3.A Enteric Fermentation

Livestock	CH_4 (kg/head)		Liveweight	Source
	EF	type	EF	
Buffalo	55	D	300 kg	**2006 IPCC Guidelines Vol. 4, Chap. 10 (10.3.2)** TABLE 10.10 Enteric fermentation emission factors for tier 1 method (page 10.28)
Sheep	5	D	45 kg	
Goats	5	D	40 kg	
Camels	46	D	570 kg	
Horses	18	D	550 kg	
Mules and Asses	10	D	245 kg	
Deer	20	D	120 kg	
Alpacas	8	D	65 kg	
Swine	1.0	D	-	
Poultry	NA[1]	-	-	
Other (e.g., Llamas)	To be determined[2]	-	-	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

[1] Insufficient data for calculation available.

[2] One approach for developing the approximate emission factors is to use the Tier 1 emissions factor for an animal with a similar digestive system and to scale the emissions factor using the ratio of the weights of the animals raised to the 0.75 power. Liveweight values have been included for this purpose. Emission factors should be derived on the basis of characteristics of the livestock and feed of interest and should not be restricted solely to within regional characteristics.

5.2.3 Uncertainties and time-series consistency for IPCC sub-category 3.A.1 Enteric Fermentation

The uncertainties for activity data and emission factors used for IPCC category *3.A.1 Enteric Fermentation* are presented in the following table.

Table 236 Uncertainty for IPCC sub-category 3.A.1 Enteric Fermentation.

Uncertainty	Cattle	Buffalo, sheep, goats, camels, horses, mules and asses	Reference
	CH_4	CH_4	2006 IPCC GL, Vol. 4, Chap. 10
Activity data: Livestock	20%	20%	Chapter 10.2.3
Activity data: Feed digestibility (DE%)	20%	-	Chapter 10.2.3
Emission factor	20%	40%	Chapter 10.3.4
Combined Uncertainty	**35%**	**45%**	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent with the data reported in in CountryStat from MAIL and FAO. The annual fluctuations of livestock in this sector is due to the Afghan War (1996–2001).

5.2.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of livestock data (statistical yearbook and FAOstat- Live Animals),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources: national statistic (NSIA, CountryStat, Agricultural Census 2003) and international statistics (FAO)

All national and international data are compared and discussed with national experts from Ministry of Agriculture Irrigation and Livestock (MAIL), National Statistics and Information Authority (NSIA), National Protection Agency (NEPA), Independent Directorate of Local Governance (IDLG), Municipality of Kabul, and University of Kabul and Kabul Polytechnic University.

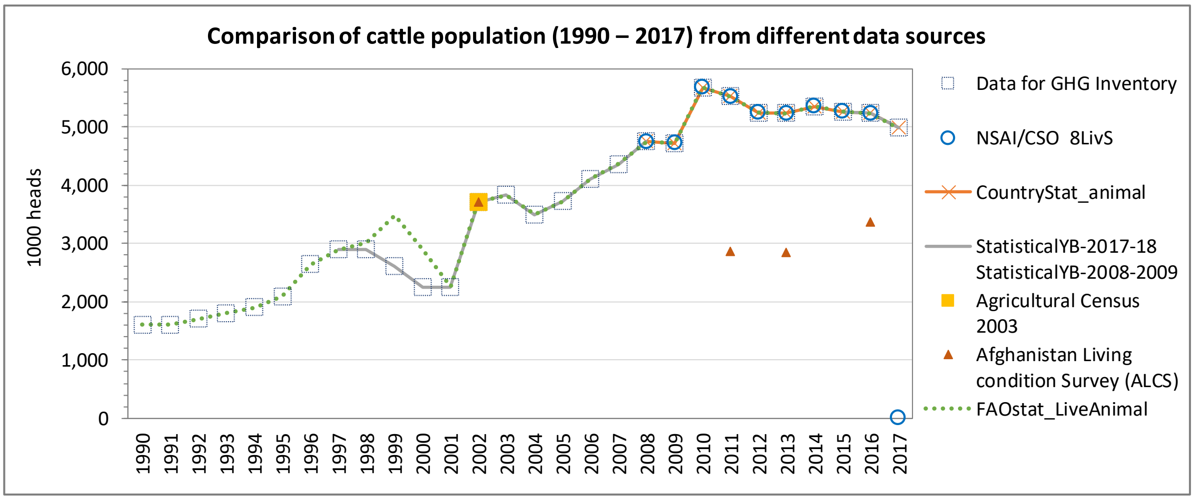


Figure 141 Comparison of cattle population (1990 – 2017) from different sources

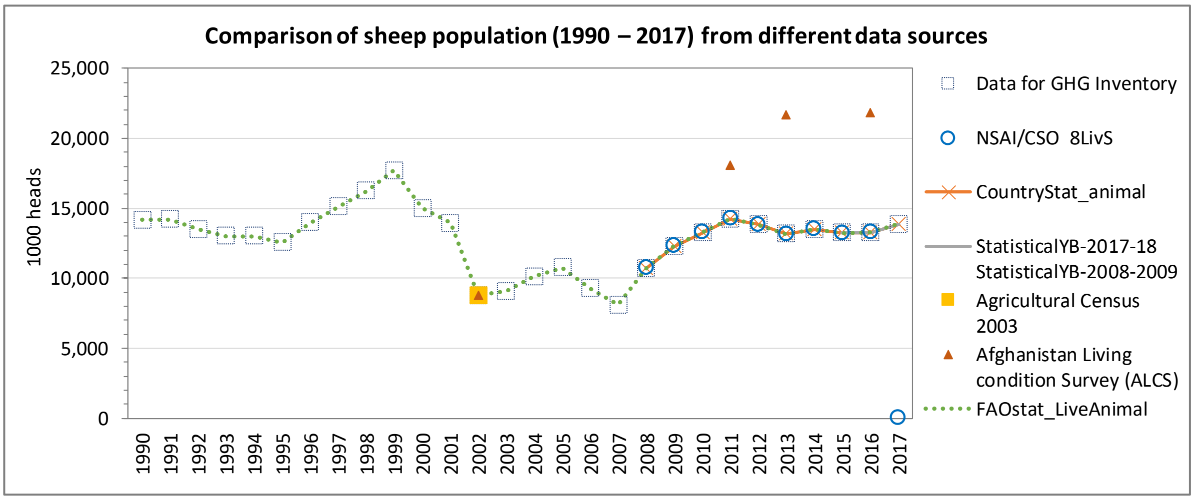


Figure 142 Comparison of sheep population (1990 – 2017) from different sources

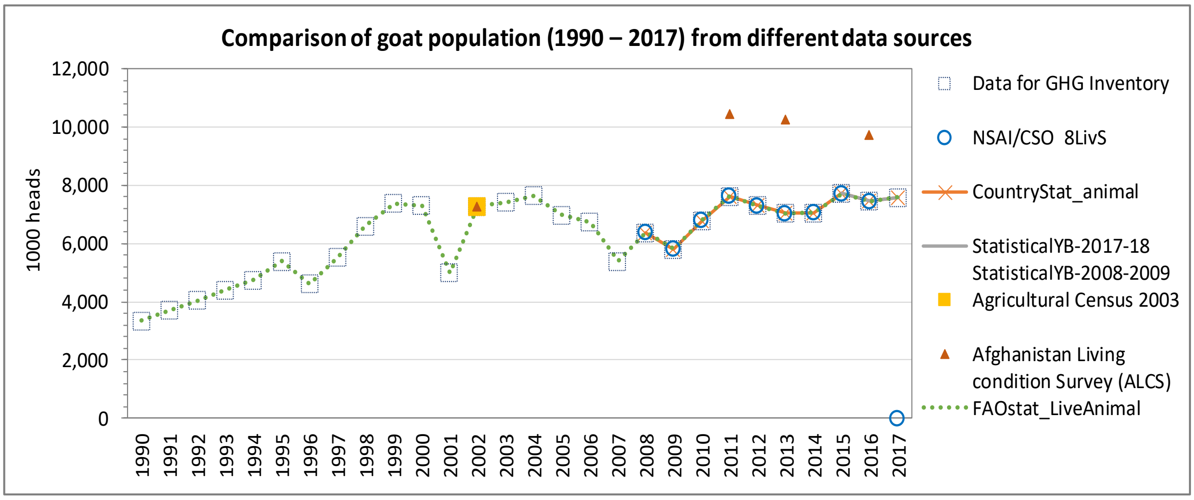


Figure 143 Comparison of goat population (1990 – 2017) from different data sources

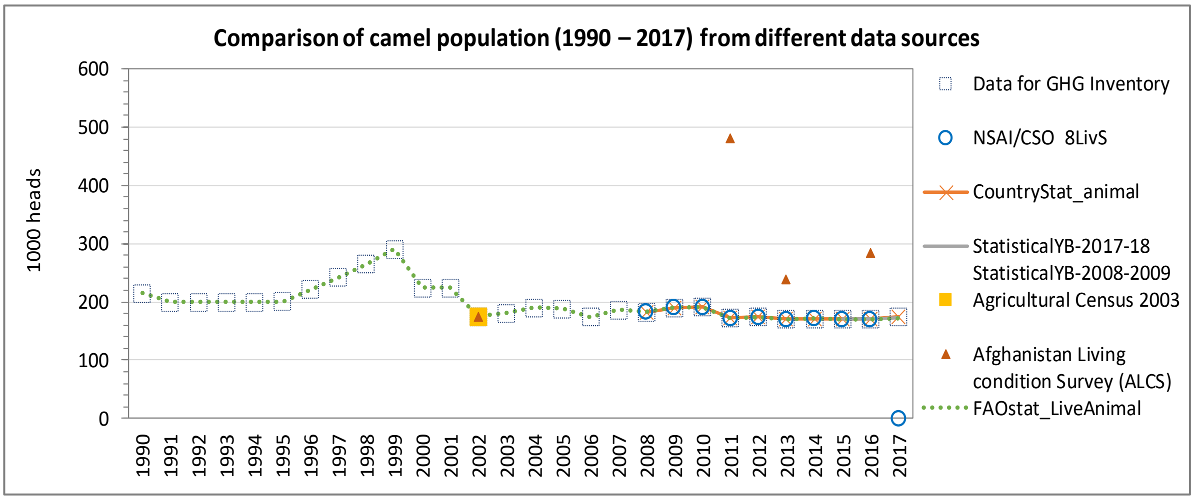


Figure 144 Comparison of camel population (1990 – 2017) from different data sources

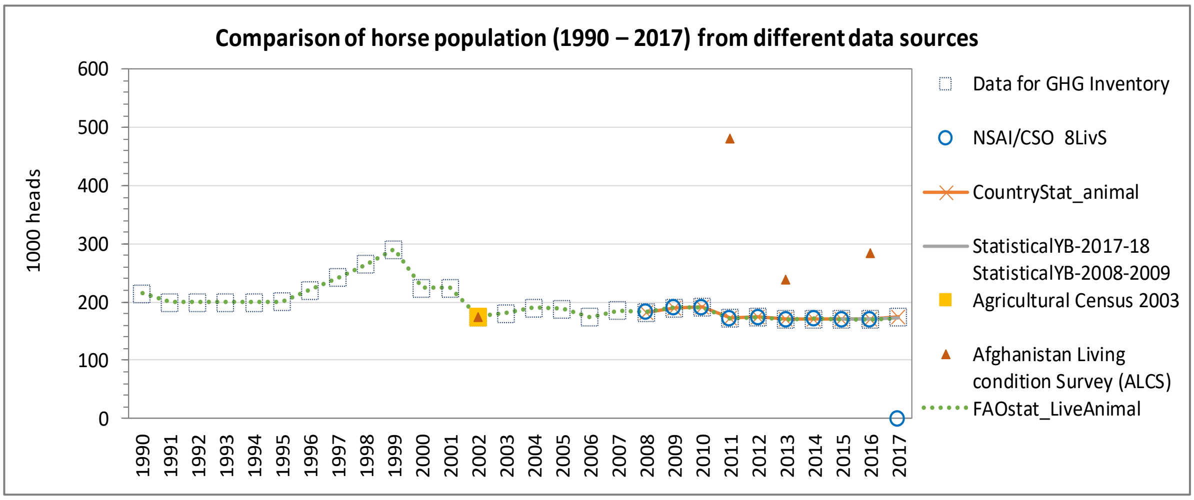


Figure 145 Comparison of horse population (1990 – 2017) from different data sources

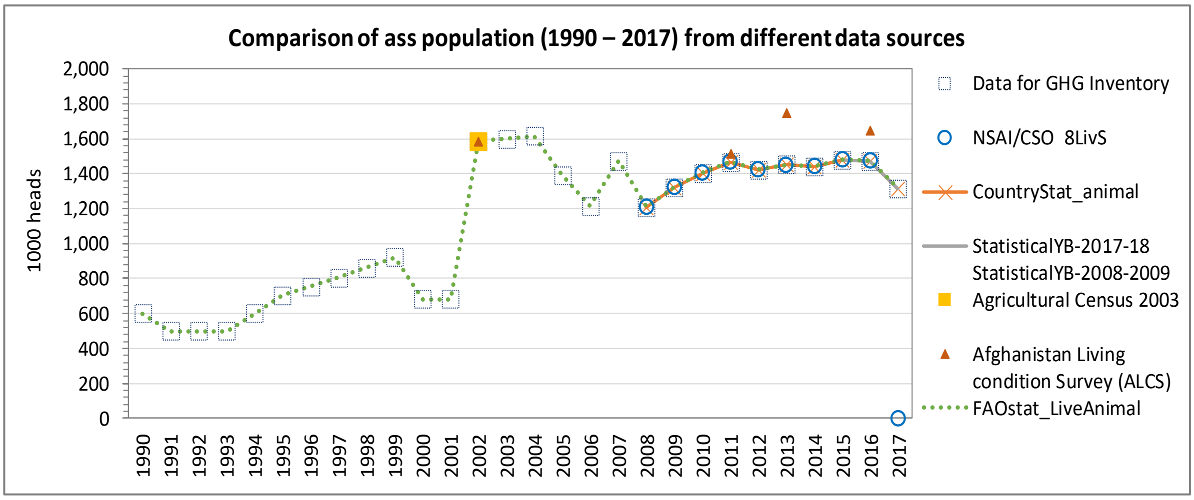


Figure 146 Comparison of ass population (1990 – 2017) from different data sources

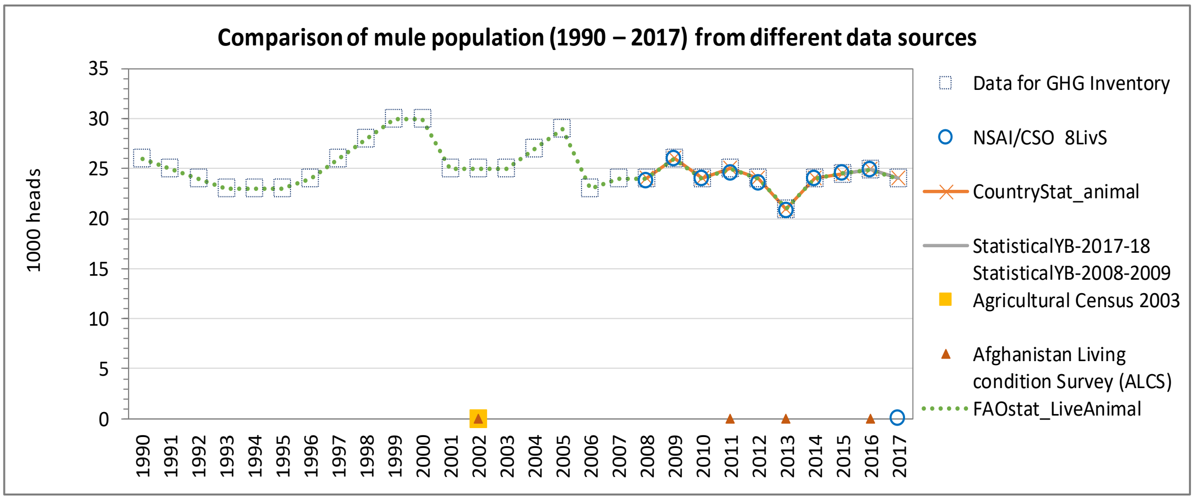


Figure 147 Comparison of mule population (1990 – 2017) from different sources

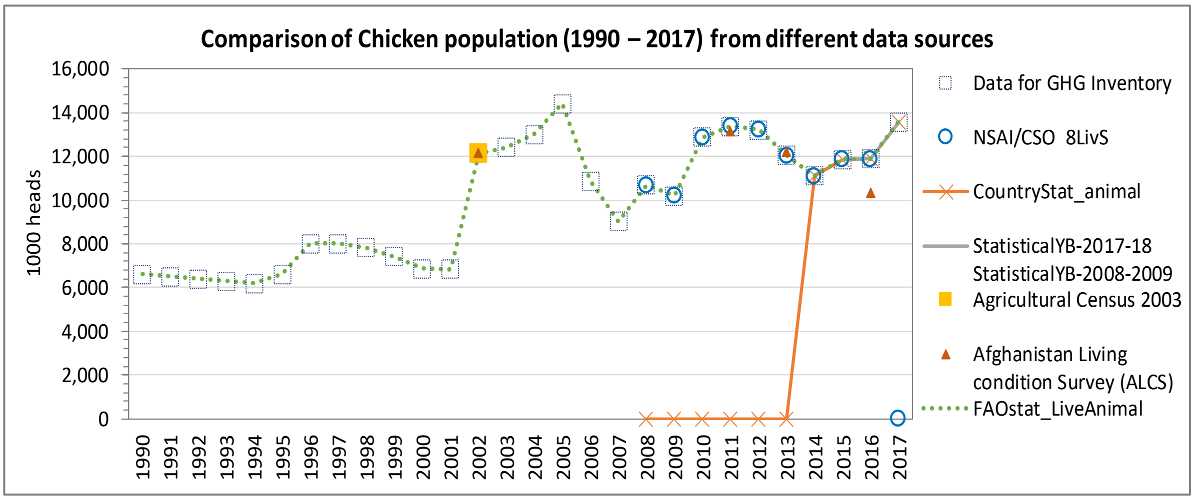


Figure 148 Comparison of chicken population (1990 – 2017) from different sources

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

5.2.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category *3.A.1 Enteric Fermentation*.

Table 237 Recalculations done since SNC in IPCC sub-category 3.A.1 Enteric Fermentation

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
3.A.1	application of 2006 IPCC Guidelines	method	Comparability
3.A.1	application of TIER 2approach for cattle	method	Comparability
3.A.1.a	use of default emission factor of 2006 IPCC Guidelines	EF	Comparability
3.A.1.b-j	use of default emission factor of 2006 IPCC Guidelines	EF	Comparability
3.A.1.a.	split of cattle in dairy, bulls and other non-dairy cattle	AD	Comparability

5.2.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 238 Planned improvements for IPCC sub-category 3.A.1 Enteric Fermentation

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.A.1	Correction of technical mistakes in calculation	AD EF	Completeness	high
3.A. 3.B. 3.D.	Survey and/or research on characteristics of Livestock Husbandry and Management Practice with consideration of regional and district as well urban and rural diversity • characteristics of Livestock Husbandry: ○ breed, ○ age distribution, ○ weight ○ milk wool yield, ○ wool yield, ○ working hours • characteristics of manure management practice: ○ stall / housed ○ pasture/range/paddock (flat/hilly) ○ grazing large areas (flat/hilly) ○ daily spread ○ solid storage ○ dry lot ○ liquid/slurry with/without natural crust cover ○ uncovered anaerobic lagoon ○ pit storage below animal confinements ○ anaerobic digester ○ burned for fuel ○ cattle and swine deep bedding ○ composting ○ aerobic treatment	AD	Accuracy Consistency Comparability Transparency Completeness	high

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.A. 3.B.	Manure management by temperature for sheep, goats, camels, horses, mules, and asses, and poultry	AD	Accuracy Comparability Transparency	medium
3.A.1.c 3.A.1.d 3.A.1.e	Estimation of methane emissions applying TIER 2 approach as these sub-categories are key categories	method	Transparency Comparability	high
3.A.1.j 3.B. 3.D	Survey and/or research on Livestock which is not included in current statistics: e.g. buffalo, llamas, alpacas, fur bearing animals	AD	Completeness	High

GHG Inventory Review Workshop ©UNEP

5.3 Manure management (IPCC category 3.B)

This section describes the estimation of methane and nitrous oxide emissions resulting during the storage and treatment of manure, and from manure deposited on pasture. The term 'manure' is used here collectively to include both dung and urine (i.e., the solids and the liquids) produced by livestock. The following figure shows a schematic overview of manure management practices.

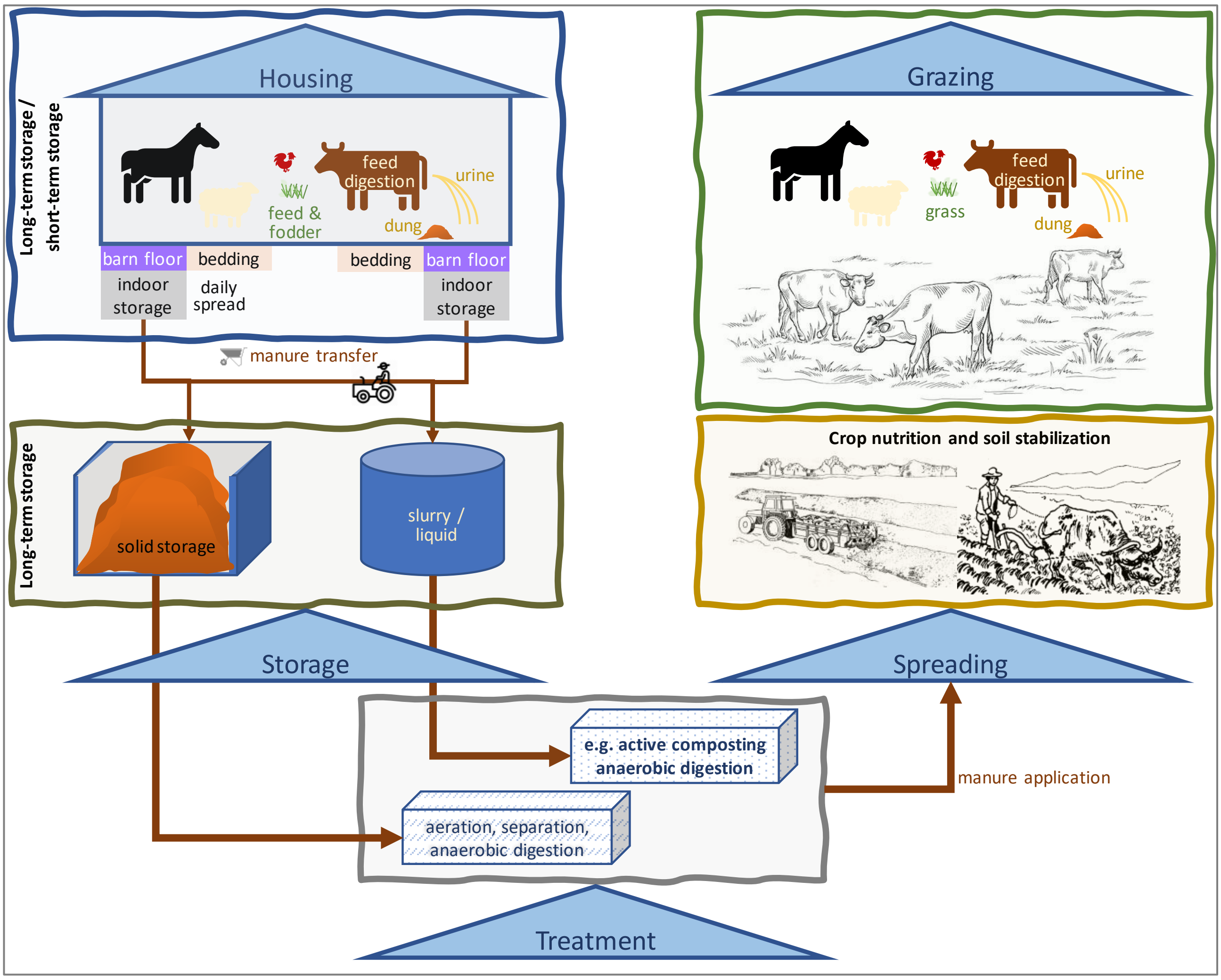


Figure 149 **Schematic overview of manure management practices**

As described in the 2006 IPCC Guidelines (Volume 4, Chapter 10.4) methane (CH_4) is produced during decomposition of manure under anaerobic conditions (i.e., in the absence of oxygen), during storage and treatment. These conditions occur most readily when large numbers of animals are managed in a confined area (e.g., dairy farms, beef feedlots, and swine and poultry farms), and where manure is disposed of in liquid-based systems.

The main factors affecting CH_4 emissions are

- the amount of manure produced:
  - ⇒ depending on the rate of waste production per animal and the number of animals
- the portion of the manure that decomposes anaerobically
  - ⇒ depending on how the manure is managed.
    - when manure is stored or treated as a liquid (e.g., in lagoons, ponds, tanks, or pits), it

decomposes anaerobically and can produce a significant quantity of CH_4. The temperature and the retention time of the storage unit greatly affect the amount of methane produced.

- when manure is handled as a solid (e.g., in stacks or piles) or when it is deposited on pastures and rangelands, it tends to decompose under more aerobic conditions and less CH_4 is produced.

In the following table are the different manure management systems and their definitions presented. The table below provides information regarding the manure management system (MMS) in Afghanistan as used in the inventory.

Table 239 Definitions of manure management systems

<table>
<tr><th colspan="2">System</th><th>Definition</th><th>Storage time of manure</th></tr>
<tr><td colspan="2">Pasture/ Range/ Paddock (PRP)</td><td>The manure from pasture and range grazing animals is allowed to lie as deposited and is not managed.</td><td>-</td></tr>
<tr><td colspan="2">Daily spread</td><td>Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.</td><td>-</td></tr>
<tr><td colspan="2">Solid storage</td><td>The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.</td><td>long period of time (months)</td></tr>
<tr><td colspan="2">Dry lot</td><td>A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.</td><td>-</td></tr>
<tr><td colspan="2">Liquid/Slurry</td><td>Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods less than one year.</td><td>≥ 6 months</td></tr>
<tr><td colspan="2">Uncovered anaerobic lagoon</td><td>A type of liquid storage system designed and operated to combine waste stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields.</td><td>30 days to >200 days</td></tr>
<tr><td colspan="2">Pit storage below animal confinements</td><td>Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility, usually for periods less than one year.</td><td>two categories:
<1 month
> 1 month</td></tr>
<tr><td colspan="2">Anaerobic digester</td><td>Animal excreta with or without straw are collected and anaerobically digested in a large containment vessel or covered lagoon. Digesters are designed and operated for waste stabilization by the microbial reduction of complex organic compounds to CO_2 and CH_4, which is captured and flared or used as a fuel.</td><td>-</td></tr>
<tr><td colspan="2">Burned for fuel</td><td>The dung and urine are excreted on fields. The sun-dried dung cakes are burned for fuel.</td><td>-</td></tr>
<tr><td colspan="2">Cattle and Swine deep bedding</td><td>As manure accumulates, bedding is continually added to absorb moisture over a production cycle and possibly for as long as 6 to 12 months. This manure management system also is known as a bedded pack manure management system and may be combined with a dry lot or pasture.</td><td>6 to 12 months</td></tr>
<tr><td rowspan="4">Composting</td><td>in- vessel</td><td>Composting, typically in an enclosed channel, with forced aeration and continuous mixing.</td><td>-</td></tr>
<tr><td>Static pile</td><td>Composting in piles with forced aeration but no mixing.</td><td>-</td></tr>
<tr><td>Intensive windrow</td><td>Composting in windrows with regular (at least daily) turning for mixing and aeration.</td><td>-</td></tr>
<tr><td>Passive windrow</td><td>Composting in windrows with infrequent turning for mixing and aeration.</td><td>-</td></tr>
<tr><td colspan="2">Poultry manure with litter</td><td>Similar to cattle and swine deep bedding except usually not combined with a dry lot or pasture. Typically used for all poultry breeder flocks and for the production of meat type chickens (broilers) and other fowl.</td><td>-</td></tr>
</table>

System	Definition	Storage time of manure
Poultry manure without litter	May be similar to open pits in enclosed animal confinement facilities or may be designed and operated to dry the manure as it accumulates. The latter is known as a high-rise manure management system and is a form of passive windrow composting when designed and operated properly.	-
Aerobic treatment	The biological oxidation of manure collected as a liquid with either forced or natural aeration. Natural aeration is limited to aerobic and facultative ponds and wetland systems and is due primarily to photosynthesis. Hence, these systems typically become anoxic during periods without sunlight.	-

Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10 Emissions from Livestock and Manure Management - sub-chapter 10.4.4 Uncertainty assessment. Table 10.18 Definitions of manure management systems. Page 10.48.

Table 240 Manure management system (MMS) in Afghanistan

		Manure System								
		Pasture Range & Paddock	Daily Spread	Solid Storage	Dry Lot	Liquid/ Slurry System	Burned for fuel	An-aerobic Lagoon	Other	Total
3.B.2.a.i	**Dairy Cattle**	50%	19%	10%	0%	1%	20%	0%	0%	100%
3.B.2.a.ii	**Other Cattle**	45%	20%	10%	4%	1%	20%	0%	0%	100%
3.B.2.b	**Buffalo**	50%	20%	20%	5%	0%	5%	0%	0%	100%
3.B.2.c	**Sheep**	50%	15%	15%	0%	0%	20%	0%	0%	100%
3.B.2.d	**Goats**	50%	15%	15%	0%	0%	20%	0%	0%	100%
3.B.2.e	**Camels**	50%	15%	15%	0%	0%	20%	0%	0%	100%
3.B.2.f	**Horses**	50%	15%	15%	0%	0%	20%	0%	0%	100%
3.B.2.g	**Mules and Asses**	50%	15%	15%	0%	0%	20%	0%	0%	100%
3.B.2.h	**Swine**	-	-	-	-	-	-	-	-	-
3.B.2.i	**Poultry**	20%	38%	10%	0%	1%	20%	0%	0%	100%

Source: FAO (2018): Nitrogen inputs to agricultural soils from livestock manure New statistics. In : Integrated Crop Management. Vol. 24 – 2018. Rome. Page 56. Available (18.02.2019) at http://www.fao.org/3/I8153EN/i8153en.pdf

As described in the 2006 IPCC Guidelines (Volume 4, Chapter 10.5) nitrous oxide (N_2O) is produced, directly and indirectly, during the storage and treatment of manure before it is applied to land or otherwise used for feed, fuel, or construction purposes.

Direct N_2O emissions occur via combined nitrification and denitrification 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, and on the duration of the storage and type of treatment. Nitrification (the oxidation of ammonia nitrogen to nitrate nitrogen) is a necessary prerequisite for the emission of N_2O from stored animal manures. Nitrification is likely to occur in stored animal manures provided there is a sufficient supply of oxygen. Nitrification does not occur under anaerobic conditions. Nitrites and nitrates are transformed to N_2O and dinitrogen (N2) during the naturally occurring process of denitrification, an anaerobic process.

Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NOx. The fraction of excreted organic nitrogen that is mineralized to ammonia nitrogen during manure collection and storage depends primarily on time, and to a lesser degree temperature. Simple forms of organic nitrogen such as urea (mammals) and uric acid (poultry) are rapidly mineralized to ammonia nitrogen, which is highly volatile and easily diffused into the surrounding air. Nitrogen losses begin at the point of excretion in houses and other animal production areas (e.g., milk parlors) and continue through on-site management in storage and treatment systems (i.e., manure management systems). Nitrogen is also lost through runoff and leaching into soils from the solid storage of manure at outdoor areas, in feedlots and where animals are grazing in pastures.

The CH_4 emissions generated by manure in the

- system ‘buildings housing livestock, manure stores or yards’ are reported under
  - ⇒ 3.B *Manure Management*
- system ‘manure handling and storage’ are reported under
  - ⇒ 3.B *Manure Management*

The N_2O emissions generated by manure in the

- system ‘pasture, range, and paddock’ occur directly and indirectly from the soil, and are therefore reported under the category
  - ⇒ 3.D.a *Direct N_2O emissions from managed soils*
    - ⇒ 3.D.a.2 *Organic N fertilizers*
      - ⇒ *3.D.a.2.a Animal manure applied to soils*
  - ⇒ 3.D.b *IndirectN_2O Emissions from managed soils*

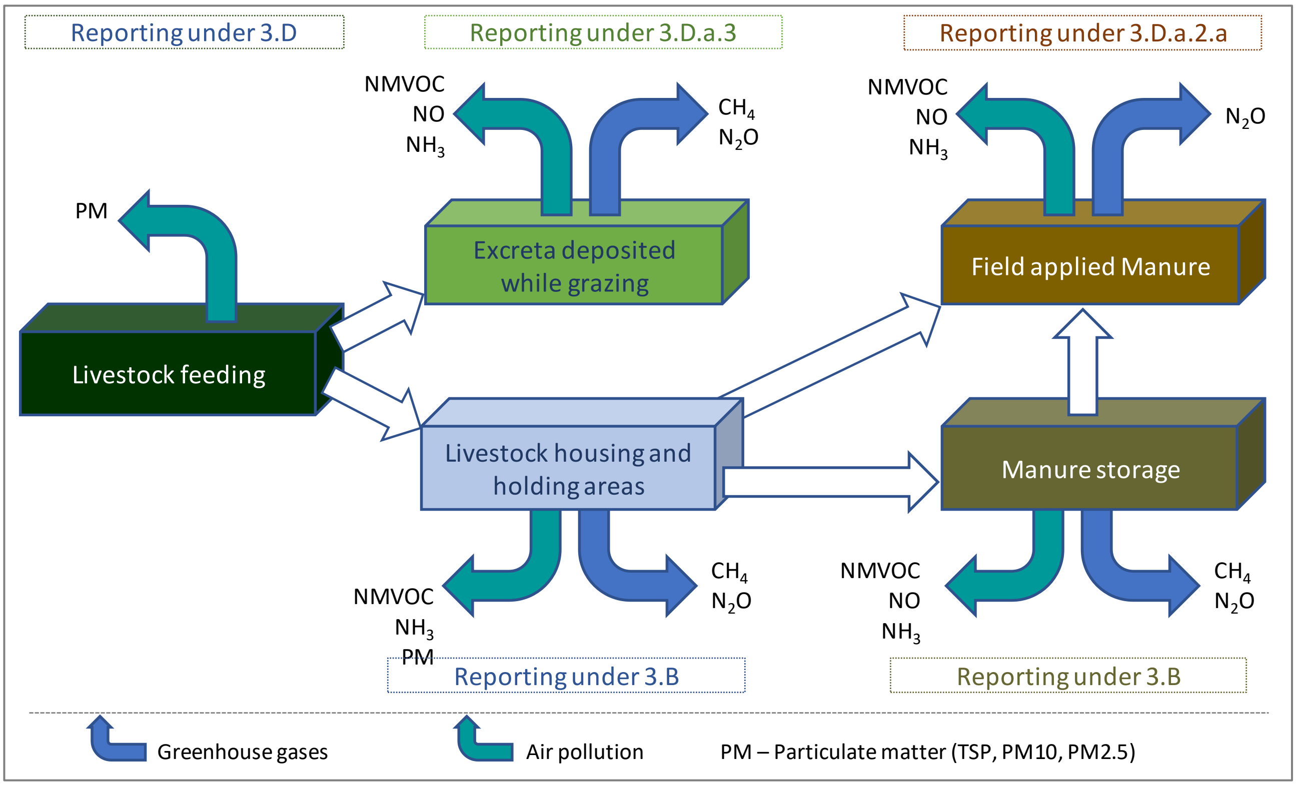


Figure 150 Scheme for emissions resulting from livestock feeding, livestock excreta and manure management

The emissions associated with the burning of dung for fuel should be reported under IPCC sector 1 Energy (if burned with energy recovery), or under IPCC sector 5 Waste (if burned without energy recovery). In Afghanistan dung is dried and used as fuel for cooking and heating. The use of dung as fuel is reported under

- CO_2 emissions from biomass burning, which is excluded from National Total GHG emissions
- CH_4 and N_2O emissions in IPCC sub-category 1.A.4.b Residential.

5.3.1 Source category description

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.B.2	**Manure Management**						
3.B.2.a	**Cattle**	NA	-	✓	LA 1990, LA 2017, TA	✓	-
3.B.2.a.i	**Dairy cows**	NA	-	✓	(yes, see cattle)	✓	-
3.B.2.a.ii	**Other cattle**	NA	-	✓	(yes, see cattle)	✓	-
3.B.2.b	**Buffalo**	NA	-	NO	-	NO	-
3.B.2.c	**Sheep**	NA	-	✓	LA 1990, LA 2017	✓	-
3.B.2.d	**Goats**	NA	-	✓	LA 2017	✓	-
3.B.2.e	**Camels**	NA	-	✓	LA 2017	✓	-
3.B.2.f	**Horses**	NA	-	✓	-	✓	-
3.B.2.g	**Mules and Asses**	NA	-	✓	-	✓	-
3.B.2.h	**Swine**	NA	-	NO	-	NO	-
3.B.2.i	**Poultry**	NA	-	✓	-	✓	-
3.B.2.i.i	**Laying hens**	NA	-	IE	-	✓	-
3.B.2.i.ii	**Broilers**	NA	-	IE	-	IE	-
3.B.2.i.iii	**Turkeys**	NA	-	IE	-	IE	-
3.B.2.i.iv	**Other poultry**	NA	-	IE	-	IE	-
3.B.2.j	**Other (please specify)**	NA	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

In 2017, this source category was responsible for

- 14% of agricultural methane (CH_4) emissions and for 13% of the total methane emissions estimated for Afghanistan.
- 2.4% of agricultural nitrous oxide (N_2O) emissions and for 2.3% of the total nitrous oxide (N_2O) emissions estimated for Afghanistan.

It represented 5% of the total GHG emissions from the agriculture sector and 11% of the total GHG emissions in CO_2eq (excluding LULUCF).

In the period 1990 – 2017 the CH_4 emissions increased by 11% and the N_2O emissions increased by 39%. In the period 2005 – 2017 the CH_4 emissions increased by 32% and the N_2O emissions increased by 19% mainly due to increased number of livestock.

Cattle are the most significant source of methane because of their high numbers, followed by sheep and goats.

The significant drop and rise in the period 1999 – 2002 and 2009/2010 are mainly due to migration of animals to and from neighboring countries during war. A severe drought in 2008 was the reason for the break in the rising trend.

An overview of the methane emissions resulting IPCC category 3.B *Manure Management* is provided in the following figure and tables.

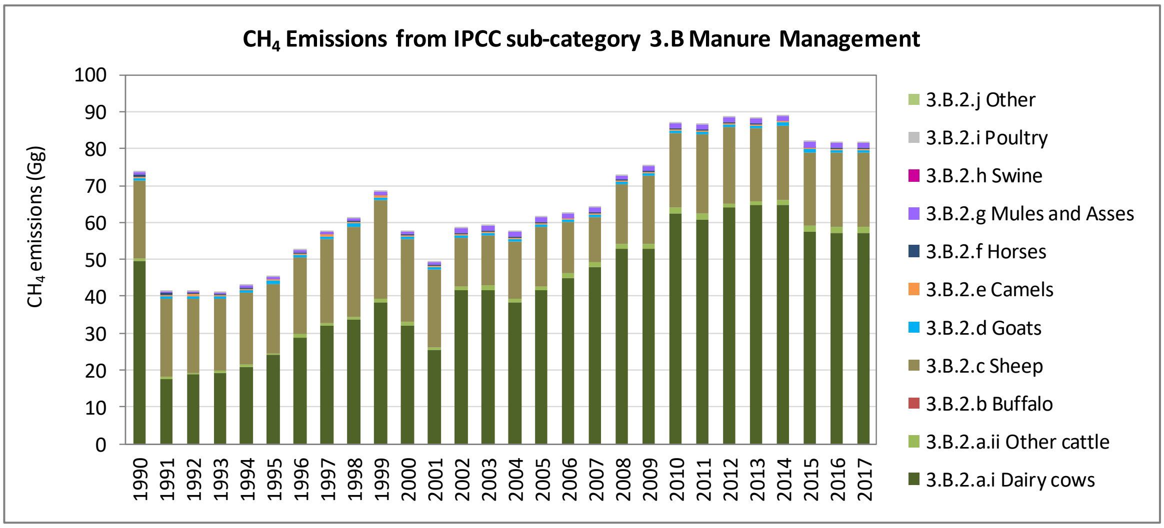


Figure 151 **CH_4 Emissions from IPCC sub-category 3.B Manure Management**

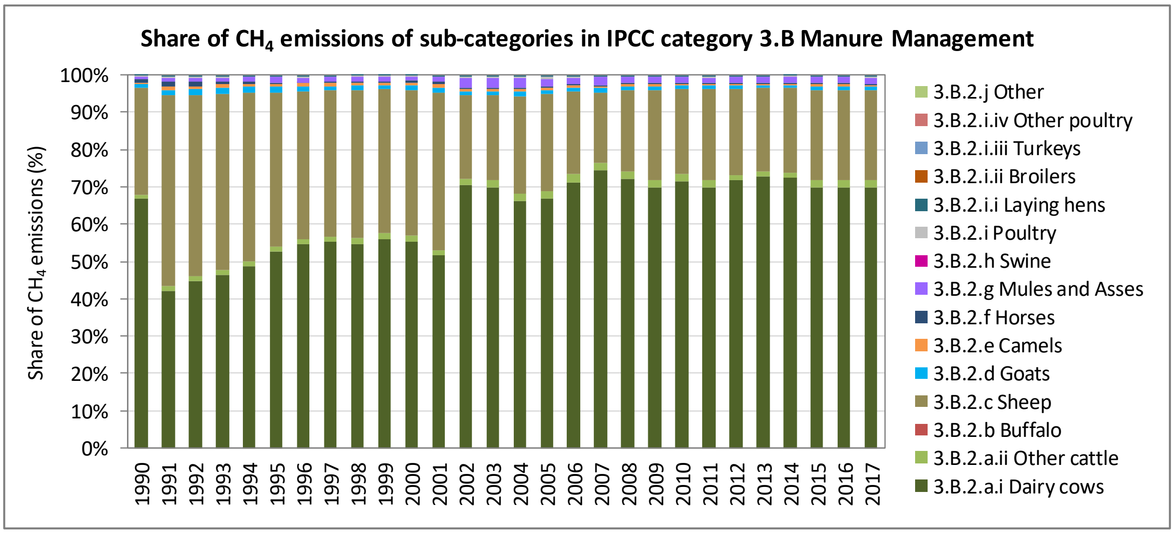


Figure 152 **Share of CH_4 emissions of sub-categories in IPCC category 3.B Manure Management**

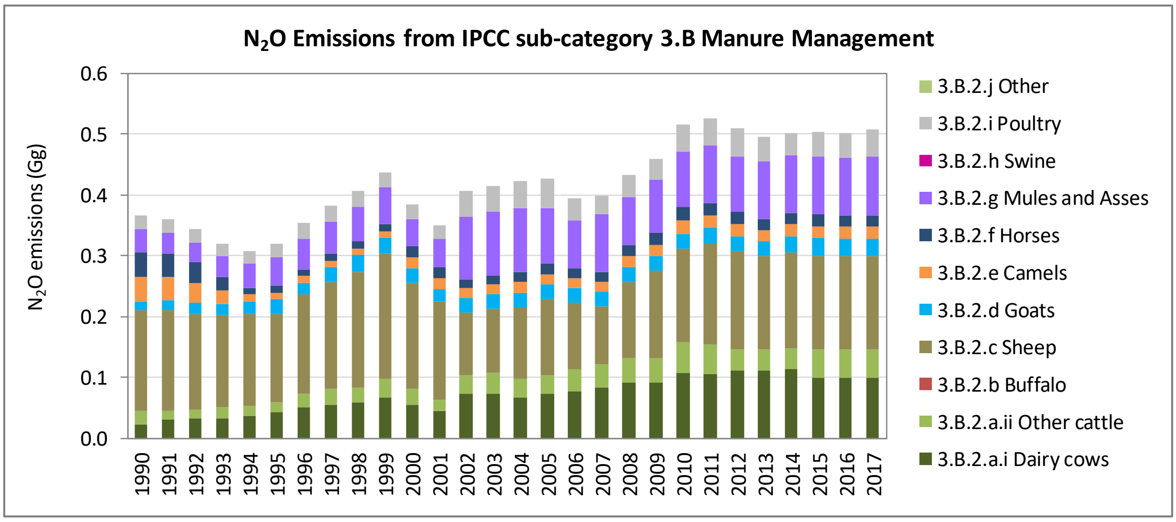


Figure 153 **N_2O Emissions from IPCC sub-category 3.B Manure Management**

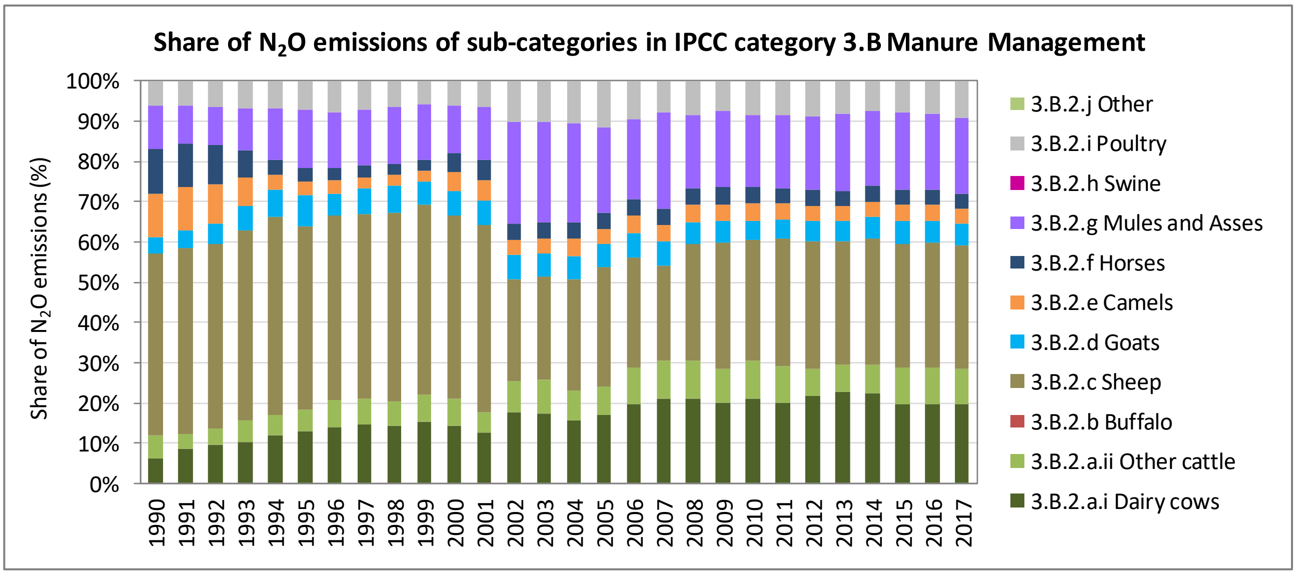


Figure 154 Share of N_2O emissions of sub-categories in IPCC category 3.B Manure Management

Zebak, Badakhshan ©Mohammad Monib Noori

Table 241 CH_4 Emissions from IPCC category 3.B Manure Management by sub-categories

CH_4 emissions Manure Management	3.B.2	3.B.2.a	3.B.2.a.i	3.B.2.a.ii	3.B.2.b	3.B.2.c	3.B.2.d	3.B.2.e	3.B.2.f	3.B.2.g	3.B.2.h	3.B.2.i	3.B.2.i.i	3.B.2.i.ii	3.B.2.i.iii	3.B.2.i.iv	3.B.2.j
		Cattle	Dairy cows	Other cattle	Buffalo	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Poultry	Laying hens	Broilers	Turkeys	Other poultry	Other
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	73.79	50.26	49.47	0.79	NO	21.26	0.57	0.41	0.59	0.56	NO	0.13	0.13	IE	IE	IE	NO
1991	41.55	18.10	17.60	0.50	NO	21.30	0.59	0.38	0.57	0.47	NO	0.13	0.13	IE	IE	IE	NO
1992	41.59	19.25	18.72	0.53	NO	20.25	0.62	0.38	0.49	0.47	NO	0.13	0.13	IE	IE	IE	NO
1993	41.25	19.80	19.20	0.60	NO	19.50	0.64	0.38	0.33	0.47	NO	0.13	0.13	IE	IE	IE	NO
1994	42.96	21.57	20.98	0.59	NO	19.50	0.66	0.38	0.16	0.56	NO	0.12	0.12	IE	IE	IE	NO
1995	45.50	24.59	24.00	0.59	NO	18.85	0.72	0.39	0.16	0.65	NO	0.13	0.13	IE	IE	IE	NO
1996	52.68	29.64	28.80	0.84	NO	20.95	0.65	0.42	0.16	0.70	NO	0.16	0.16	IE	IE	IE	NO
1997	57.81	32.90	32.00	0.90	NO	22.67	0.72	0.46	0.16	0.75	NO	0.16	0.16	IE	IE	IE	NO
1998	61.30	34.51	33.60	0.91	NO	24.38	0.78	0.51	0.16	0.80	NO	0.16	0.16	IE	IE	IE	NO
1999	68.49	39.48	38.40	1.08	NO	26.54	0.75	0.56	0.17	0.85	NO	0.15	0.15	IE	IE	IE	NO
2000	57.59	32.90	32.00	0.90	NO	22.50	0.72	0.43	0.27	0.64	NO	0.14	0.14	IE	IE	IE	NO
2001	49.32	26.25	25.60	0.65	NO	20.93	0.66	0.43	0.27	0.64	NO	0.14	0.14	IE	IE	IE	NO
2002	58.87	42.72	41.60	1.12	NO	13.16	0.73	0.34	0.23	1.45	NO	0.24	0.24	IE	IE	IE	NO
2003	59.45	42.83	41.60	1.23	NO	13.61	0.72	0.35	0.24	1.46	NO	0.25	0.25	IE	IE	IE	NO
2004	57.78	39.49	38.40	1.09	NO	15.20	0.72	0.36	0.25	1.48	NO	0.26	0.26	IE	IE	IE	NO
2005	61.78	42.72	41.60	1.12	NO	16.16	0.72	0.36	0.24	1.28	NO	0.29	0.29	IE	IE	IE	NO
2006	62.62	46.11	44.80	1.31	NO	13.89	0.72	0.33	0.24	1.11	NO	0.22	0.22	IE	IE	IE	NO
2007	64.36	49.36	48.00	1.36	NO	12.16	0.73	0.36	0.24	1.35	NO	0.18	0.18	IE	IE	IE	NO
2008	72.98	54.25	52.80	1.45	NO	16.07	0.73	0.35	0.27	1.11	NO	0.21	0.21	IE	IE	IE	NO
2009	75.45	54.22	52.80	1.42	NO	18.43	0.73	0.36	0.29	1.21	NO	0.20	0.20	IE	IE	IE	NO

CH_4 emissions	3.B.2	3.B.2.a	3.B.2.a.i	3.B.2.a.ii	3.B.2.b	3.B.2.c	3.B.2.d	3.B.2.e	3.B.2.f	3.B.2.g	3.B.2.h	3.B.2.i	3.B.2.i.i	3.B.2.i.ii	3.B.2.i.iii	3.B.2.i.iv	3.B.2.j
Manure Managem ent		Cattle	Dairy cows	Other cattle	Buffalo	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Poultry	Laying hens	Broilers	Turkeys	Other poultry	Other
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
2010	87.06	64.17	62.40	1.77	NO	19.93	0.72	0.37	0.32	1.29	NO	0.26	0.26	IE	IE	IE	NO
2011	86.90	62.52	60.80	1.72	NO	21.39	0.75	0.33	0.30	1.34	NO	0.27	0.27	IE	IE	IE	NO
2012	88.90	65.24	64.00	1.24	NO	20.73	0.73	0.33	0.29	1.30	NO	0.26	0.26	IE	IE	IE	NO
2013	88.44	65.84	64.64	1.20	NO	19.71	0.72	0.33	0.28	1.32	NO	0.24	0.24	IE	IE	IE	NO
2014	89.24	66.10	64.80	1.30	NO	20.23	0.76	0.33	0.28	1.32	NO	0.22	0.22	IE	IE	IE	NO
2015	82.01	59.19	57.52	1.67	NO	19.83	0.80	0.33	0.28	1.35	NO	0.24	0.24	IE	IE	IE	NO
2016	81.79	58.91	57.26	1.66	NO	19.90	0.78	0.33	0.28	1.35	NO	0.24	0.24	IE	IE	IE	NO
2017	81.83	58.91	57.26	1.66	NO	19.90	0.79	0.33	0.28	1.35	NO	0.27	0.27	IE	IE	IE	NO
Trend																	
1990 - 2017	*10.9%*	*17.2%*	*15.7%*	*108.7%*	*NA*	*-6.4%*	*38.7%*	*-20.7%*	*-52.7%*	*139.1%*	*NA*	*105.7%*	*105.7%*	*NA*	*NA*	*NA*	*NA*
2005 - 2017	*32.5%*	*37.9%*	*37.6%*	*47.5%*	*NA*	*23.1%*	*9.1%*	*-9.3%*	*14.9%*	*5.4%*	*NA*	*-5.8%*	*-5.8%*	*NA*	*NA*	*NA*	*NA*
2016 - 2017	*0.1%*	*0.0%*	*0.0%*	*0.0%*	*NA*	*0.0%*	*1.0%*	*0.0%*	*0.0%*	*0.0%*	*NA*	*14.1%*	*14.1%*	*NA*	*NA*	*NA*	*NA*

Table 242 N_2O Emissions from IPCC category 3.B Manure Management by sub-categories

N_2O emissions Manure Management	3.B.2	3.B.2.a	3.B.2.a.i	3.B.2.a.ii	3.B.2.b	3.B.2.c	3.B.2.d	3.B.2.e	3.B.2.f	3.B.2.g	3.B.2.h	3.B.2.i	3.B.2.i.i	3.B.2.i.ii	3.B.2.i.iii	3.B.2.i.iv	3.B.2.j
		Cattle	Dairy cows	Other cattle	Buffalo	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Poultry	Laying hens	Broilers	Turkeys	Other poultry	Other
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	0.37	0.04	0.02	0.02	NO	0.17	0.01	0.04	0.04	0.04	NO	0.02	0.02	IE	IE	IE	NO
1991	0.36	0.04	0.03	0.01	NO	0.17	0.02	0.04	0.04	0.03	NO	0.02	0.02	IE	IE	IE	NO
1992	0.34	0.05	0.03	0.01	NO	0.16	0.02	0.03	0.03	0.03	NO	0.02	0.02	IE	IE	IE	NO
1993	0.32	0.05	0.03	0.02	NO	0.15	0.02	0.02	0.02	0.03	NO	0.02	0.02	IE	IE	IE	NO
1994	0.31	0.05	0.04	0.02	NO	0.15	0.02	0.01	0.01	0.04	NO	0.02	0.02	IE	IE	IE	NO
1995	0.32	0.06	0.04	0.02	NO	0.15	0.02	0.01	0.01	0.05	NO	0.02	0.02	IE	IE	IE	NO
1996	0.35	0.07	0.05	0.02	NO	0.16	0.02	0.01	0.01	0.05	NO	0.03	0.03	IE	IE	IE	NO
1997	0.38	0.08	0.06	0.02	NO	0.18	0.02	0.01	0.01	0.05	NO	0.03	0.03	IE	IE	IE	NO
1998	0.41	0.08	0.06	0.03	NO	0.19	0.03	0.01	0.01	0.06	NO	0.03	0.03	IE	IE	IE	NO
1999	0.44	0.10	0.07	0.03	NO	0.21	0.03	0.01	0.01	0.06	NO	0.03	0.03	IE	IE	IE	NO
2000	0.38	0.08	0.06	0.03	NO	0.17	0.02	0.02	0.02	0.05	NO	0.02	0.02	IE	IE	IE	NO
2001	0.35	0.06	0.04	0.02	NO	0.16	0.02	0.02	0.02	0.05	NO	0.02	0.02	IE	IE	IE	NO
2002	0.41	0.10	0.07	0.03	NO	0.10	0.02	0.02	0.02	0.10	NO	0.04	0.04	IE	IE	IE	NO
2003	0.41	0.11	0.07	0.03	NO	0.11	0.02	0.02	0.02	0.10	NO	0.04	0.04	IE	IE	IE	NO
2004	0.42	0.10	0.07	0.03	NO	0.12	0.02	0.02	0.02	0.11	NO	0.04	0.04	IE	IE	IE	NO
2005	0.43	0.10	0.07	0.03	NO	0.13	0.02	0.02	0.02	0.09	NO	0.05	0.05	IE	IE	IE	NO
2006	0.39	0.11	0.08	0.04	NO	0.11	0.02	0.02	0.02	0.08	NO	0.04	0.04	IE	IE	IE	NO
2007	0.40	0.12	0.08	0.04	NO	0.09	0.02	0.02	0.02	0.10	NO	0.03	0.03	IE	IE	IE	NO
2008	0.43	0.13	0.09	0.04	NO	0.12	0.02	0.02	0.02	0.08	NO	0.04	0.04	IE	IE	IE	NO
2009	0.46	0.13	0.09	0.04	NO	0.14	0.02	0.02	0.02	0.09	NO	0.03	0.03	IE	IE	IE	NO

N_2O emissions	3.B.2	3.B.2.a	3.B.2.a.i	3.B.2.a.ii	3.B.2.b	3.B.2.c	3.B.2.d	3.B.2.e	3.B.2.f	3.B.2.g	3.B.2.h	3.B.2.i	3.B.2.i.i	3.B.2.i.ii	3.B.2.i.iii	3.B.2.i.iv	3.B.2.j
Manure Management		Cattle	Dairy cows	Other cattle	Buffalo	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Poultry	Laying hens	Broilers	Turkeys	Other poultry	Other
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
2010	0.52	0.16	0.11	0.05	NO	0.15	0.02	0.02	0.02	0.09	NO	0.04	0.04	IE	IE	IE	NO
2011	0.53	0.15	0.11	0.05	NO	0.17	0.03	0.02	0.02	0.10	NO	0.05	0.05	IE	IE	IE	NO
2012	0.51	0.15	0.11	0.03	NO	0.16	0.02	0.02	0.02	0.09	NO	0.04	0.04	IE	IE	IE	NO
2013	0.50	0.15	0.11	0.03	NO	0.15	0.02	0.02	0.02	0.09	NO	0.04	0.04	IE	IE	IE	NO
2014	0.50	0.15	0.11	0.04	NO	0.16	0.03	0.02	0.02	0.09	NO	0.04	0.04	IE	IE	IE	NO
2015	0.50	0.15	0.10	0.05	NO	0.15	0.03	0.02	0.02	0.10	NO	0.04	0.04	IE	IE	IE	NO
2016	0.50	0.15	0.10	0.05	NO	0.15	0.03	0.02	0.02	0.10	NO	0.04	0.04	IE	IE	IE	NO
2017	0.51	0.15	0.10	0.05	NO	0.15	0.03	0.02	0.02	0.10	NO	0.05	0.05	IE	IE	IE	NO
Trend																	
1990 - 2017	*38.6%*	*227.2%*	*343.7%*	*108.7%*	*NA*	*-6.4%*	*96.8%*	*-52.7%*	*-52.7%*	*139.1%*	*NA*	*105.7%*	*105.7%*	*NA*	*NA*	*NA*	*NA*
2005 - 2017	*19.3%*	*40.6%*	*37.6%*	*47.5%*	*NA*	*23.1%*	*17.2%*	*14.9%*	*14.9%*	*5.4%*	*NA*	*-5.8%*	*-5.8%*	*NA*	*NA*	*NA*	*NA*
2016 - 2017	*1.2%*	*0.0%*	*0.0%*	*0.0%*	*NA*	*0.0%*	*1.8%*	*0.0%*	*0.0%*	*0.0%*	*NA*	*14.1%*	*14.1%*	*NA*	*NA*	*NA*	*NA*

5.3.2 Methodological issues

5.3.2.1 Choice of methods

For estimating the

- The CH_4 emissions from all livestock the 2006 IPCC Guidelines Tier 1 approach[155] has been applied.
- direct and indirect N_2O emissions from all livestock the 2006 IPCC Guidelines Tier 1 approach[156] has been applied.

TIER 1 approach – methane emissions

Tier 1 is simplified method that only requires livestock population data by animal species/category and climate region or temperature, in combination with IPCC default emission factors, to estimate emissions. Because some emissions from manure management systems are highly temperature dependent, it is good practice to estimate the average annual temperature associated with the locations where manure is managed.

Equation 10.22: CH_4 emissions from manure management from a livestock category

$$\boldsymbol{Emissions_{CH4} = Livestock_{\ category} \times \left(\frac{Emission\ Factor_T}{10^6}\right)}$$

Where:

Emissions $_{CH4}$	= CH_4 emissions (Gg CH_4)
Livestock $_{category}$	= number of head of livestock species / category T
Emission factor $_T$	= default emission factor for a defined livestock population (kg CH_4 head^{-1}).
T	= species/category of livestock

Finally, the total emissions from the species/category of livestock was estimated applying the following equation:

Total emissions from livestock manure management

$$\boldsymbol{Emissions_{CH4\ manure} = \sum_i emissions_i}$$

Where:

Emissions $_{CH4\ manure}$	= total CH_4 emissions from Manure Management (Gg CH_4)
Emission $_i$	= emissions for the ith livestock categories and subcategories.

TIER 1 approach – Direct N_2O emissions from Manure Management

The Tier 1 method entails multiplying the total amount of N excretion (from all livestock species/categories) in each type of manure management system by an emission factor for that type of manure management system (*see below Equation 10.25*). Emissions are then summed over all manure management systems. The Tier 1 method is applied using IPCC default N_2O emission factors, default nitrogen excretion data, and default manure management system data.

Equation 10.25: Direct N_2O emissions from Manure Management

$$\boldsymbol{Emissions_{N2O} = \left[\sum_S \left[\sum_T \left(N_T \times Nex_{(T)} \times MS_{(T,S)}\right)\right] \times EF_{3(S)}\right] \times \frac{44}{28}}$$

[155] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10 Emissions from Livestock and Manure Management, sub-chap 10.4.1 Choice of method

[156] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10 Emissions from Livestock and Manure Management, sub-chap 10.5.1 Choice of method

Where:

$N_2O_{D(mm)}$	= direct N_2O emissions from Manure Management in the country (kg N_2O)
$N_{(T)}$	= number of head of livestock species/category T in the country
$Nex_{(T)}$	= annual average N excretion per head of species/category T in the country (kg N / animal)
$MS_{(T,S)}$	= fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless
$EF_{3(S)}$	= emission factor for direct N_2O emissions from manure management system S in the country (kg N_2O-N/kg N in manure management system S)
S	= manure management system
T	= species/category of livestock
44/28	= conversion of $(N_2O\text{-}N)_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions

Following the guidance provided in the 2006 IPCCC guidelines (Volume 4, Chapter 10.5.1) the following five steps were used to estimate direct N_2O emissions from Manure Management:

Step 1: Collect population data from the Livestock Population Characterization;

Step 2: Use default values or develop the annual average nitrogen excretion rate per head (Nex(T)) for each defined livestock species/category T;

Step 3: Use default values or determine the fraction of total annual nitrogen excretion for each livestock species/category T that is managed in each manure management system S ($MS_{(T,S)}$);

Step 4: Use default values or develop N_2O emission factors for each manure management system S (EF3(S));

Step 5: For each manure management system type S, multiply its emission factor ($EF_{3(S)}$) by the total amount of nitrogen managed (from all livestock species/categories) in that system, to estimate N_2O emissions from that manure management system. Then sum over all manure management systems.

There may be losses of nitrogen in other forms (e.g., ammonia and NOx) as manure is managed on site. Nitrogen in the volatilized form of ammonia may be deposited at sites downwind from manure handling areas and contribute to indirect N_2O emissions (see below).

TIER 1 approach – Indirect N_2O emissions from Manure Management

The Tier 1 calculation of N volatilization in forms of NH_3 and NO_x from manure management systems is based on multiplication of the amount of nitrogen excreted (from all livestock categories) and managed in each manure management system by a fraction of volatilized nitrogen (see below Equation 10.26). Nitrogen (N) losses are then summed over all manure management systems.

The Tier 1 method was applied using

- default nitrogen excretion data,
- default manure management system data and
- default fractions of N losses from manure management systems due to volatilization.

Equation 10.26: Nitrogen (N) losses due to volatilization from manure management

$$\boldsymbol{N_{volatilzation-MMS}} = \left[\sum_{S}\left[\sum_{T}\left(\boldsymbol{N_T} \times \boldsymbol{Nex_{(T)}} \times \boldsymbol{MS_{(T,S)}}\right) \times \left(\frac{\boldsymbol{Frac_{GasMS}}}{\mathbf{100}}\right)_{(T,S)}\right]\right]$$

Where:

$N_{volatilization-MMS}$ = amount of manure nitrogen that is lost due to volatilization of NH_3 and NOx (kg N)

$N_{(T)}$ = number of head of livestock species/category T in the country
$Nex_{(T)}$ = annual average N excretion per head of species/category T in the country (kg N / animal)
$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless
$Frac_{GasMS}$ = percent of managed manure nitrogen for livestock category T that volatilizes as NH_3 and NO_x in the manure management system S (%)

The indirect N_2O emissions from volatilisation of N in forms of NH_3 and NOx ($N_2O_{G(mm)}$) are estimated using the following equation:

Equation 10.27: Indirect N_2O emissions due to volatilization of N from manure management

$$\boldsymbol{Indirect\ emissions\ N_2O_{manure\ management}} = (\boldsymbol{N}_{\text{volatilization}-\text{MMS}} \times \boldsymbol{EF_4}) \times \frac{\mathbf{44}}{\mathbf{28}}$$

Where:
$N_2O_{G(mm)}$ = indirect N_2O emissions due to volatilization of N from Manure Management in the country (kg N_2O)
EF_4 = emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces (kg N_2O-N (kg NH3-N + NOx-N volatilised)$^{-1}$
with default value 0.01 kg N_2O-N (kg NH3-N +NOx-N volatilised)$^{-1}$

5.3.2.2 Choice of activity data

As described in Chapter 05.1.3 above, the agricultural data used and presented in this inventory are taken from national and international sources:

- Afghanistan National Livestock Census[127]
- Afghanistan Statistical yearbook[128]
- CountrySTAT[129]
- FAO agricultural data base[130]

Additional national publications such as ALCS (different years) were used to cross-check the used statistics. The original data provider for the national and international database is the Ministry of Agriculture Irrigation and Livestock (MAIL).

Detailed data and relevant description are provided in Chapter 5.2.2.2.

5.3.2.3 Choice of emission factors

Default emission factors for methane (CH_4)

The default emission factors for methane (CH_4) were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 243 Emission factors for Tier 1 for IPCC sub-category 3.B Manure Management

Livestock	CH_4 emission factor by average annual temperature (°C) (kg/head per year)		Region / average annual temperature	Source
	EF	type	EF	
Dairy Cows	16	D	Asia: 18°	**2006 IPCC Guidelines Vol. 4, Chap. 10 (10.4.2)** Table 10.14 Manure management methane emission factors by temperature (page 10.38ff)
Other Cattle	1	D		
Buffalo	5	D		
Swine	3.0	D		

Livestock	CH_4 emission factor by average annual temperature (°C) (kg/head per year)		Region / average annual temperature	Source
	EF	type	EF	
Sheep	0.15	D	Developing countries / Temperate (15 to 25°C)	**2006 IPCC Guidelines Vol. 4, Chap. 10 (10.4.2)** Table 10.15 Manure management methane emission factors by temperature (page 10.40)
Goats	0.17	D		
Camels	1.92	D		
Horses	1.64	D		
Mules and Asses	0.9	D		
Poultry	0.02	D		
Note: D Default; CS Country specific; PS Plant specific; IEF Implied emission factor				

Nitrous oxide (N_2O) - Annual average nitrogen excretion rates ($Nex_{(T)}$)

The TIER 1 Annual average nitrogen excretion rates ($Nex_{(T)}$) was calculated according to Equation 10.30 of 2006 IPCC GL[157] and are presented in the following table.

Equation 10.30: Annual N excretion rates (2006 IPCC GL, Vol. 4, Chap. 10)

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

Where:

$Nex_{(T)}$ = annual N excretion for livestock category T (kg N animal^{-1} $^{yr-1}$)

$N_{rate(T)}$ = default N excretion rate (kg N (1000 kg animal mass)$^{-1}$ day^{-1})

$TAM_{(T)}$ = typical animal mass for livestock category T (kg animal^{-1})

Annual average nitrogen excretion rate $N_{rate(T)}$

Annual nitrogen excretion rates should be determined for each livestock category defined by the livestock population characterization. As no country specific nitrogen excretion rate $N_{rate(T)}$ were available, the default N excretion rates were used. They are presented in the following table.

Table 244 Typical animal mass, default nitrogen excretion rate and annual N excretion for livestock category

	Category of animal	Typical animal mass for livestock $TAM_{(T)}$ (kg)	Default values for nitrogen excretion rate ($N_{rate(T)}$) (kg N (1000 kg animal mass)$^{-1}$ day^{-1})	Annual N excretion for livestock category (kg N animal-1 $^{yr-1}$)
			Region - Asia	
3.B.2.a.i	Dairy Cattle	233.75	0.47	40.10
3.B.2.a.ii	Other Cattle	200.00	0.34	24.82
3.B.2.b	Other - Dairy Buffalo	300.00	0.3	35.04
3.B.2.c	Other - Sheep	45.00	1.17	19.22
3.B.2.d	Other - Goats	40.00	1.37	20.00
3.B.2.e	Other - Camels	570.00	0.46	95.70

[157] 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10 Emissions from Livestock and Manure Management, sub-chap 10.5.2 Choice of emission factors. Equation 10.30. page 10.57.

	Category of animal	Typical animal mass for livestock $TAM_{(T)}$ (kg)	Default values for nitrogen excretion rate ($N_{rate(T)}$) (kg N (1000 kg animal mass)$^{-1}$ day^{-1})	Annual N excretion for livestock category (kg N animal-1 $^{yr-1}$)
			Region - Asia	
3.B.2.f	Other - Horses	550.00	0.46	92.35
3.B.2.g	Other - Mules and Asses	245.00	0.46	41.14
3.B.2.h	Swine	-	0.40	-
3.B.2.i	Other - Poultry	2.00	0.82	0.60
Source:		*FAO (2008)*[158]	*Table 10.19 Default values for nitrogen excretion rate*[159]	*calculated*

The direct N_2O emissions are exemplarily calculated in Table 246 (direct N_2O emissions) applying the default emission factors for direct N_2O emissions from manure management (see Table 245).

Table 245 Default emission factors for direct N_2O emissions from manure management

System	Definition		EF_3 [kg N_2O-N (kg Nitrogen excreted)$^{-1}$]
Pasture/Range/ Paddock	The manure from pasture and range grazing animals is allowed to lie as it is and is not managed.		NA
Daily spread	Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion. N_2O emissions during storage and treatment are assumed to be zero. N_2O emissions from land application are covered under the Agricultural Soils category.		0
Solid storage	The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.		0.005
Dry lot	A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically. Dry lots are most typically found in dry climates but also are used in humid climates.		0.02
Liquid/Slurry	Manure is stored as excreted or with some minimal addition of water to facilitate handling and is stored in either tanks or earthen ponds.	With natural crust cover	0.005
		Without natural crust cover	0
Uncovered anaerobic lagoon	Anaerobic lagoons are designed and operated to combine waste stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields.		0

[158] FAO AFG (2008): First Draft Country Report on the Status and Perspectives of the Animal Genetic Resources Development and Conservation in Afghanistan. Available on 05.04.2019 at: http://www.fao.org/tempref/docrep/fao/010/a1250e/annexes/CountryReports/Afghanistan.pdf

[159] 2006 IPCC Guidelines, Vol. 4, Chap. 10, sub-chap. 10.5.2 Choice of emission factors, page 10.59.

System	Definition	EF_3 [kg N_2O-N (kg Nitrogen excreted)$^{-1}$]
Pit storage below animal confinements	Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility.	0.002
Remark: Direct and indirect N_2O emissions associated with the manure deposited on agricultural soils and pasture, range, paddock systems are treated under 3.D N_2O emissions from managed soils.		
Remark: The emissions associated with the burning of dung for fuel should be reported under IPCC sector 1 Energy (if burned with energy recovery), or under IPCC sector 5 Waste (if burned without energy recovery). In Afghanistan dung is dried and used as fuel for cooking and heating. The use of dung as fuel is reported under • CO_2 emissions from biomass burning, which is excluded from National Total GHG emissions • CH_4 and N_2O emissions in IPCC sub-category 1.A.4.b Residential.		

Source: 2006 IPCC Guidelines, Vol. 4, Chap. 10, sub-chap. 10.5.3 Choice of emission factors, Table 10.21 Default emission factors for direct N_2O emissions from manure management; page 10.62.

In Afghanistan it is common to use dung as fuel. When estimating the $Nex_{(T)}$ for animals whose manure is classified in the manure management system burned for fuel, it should be kept in mind that the dung is burned, and the urine stays in the field. As a rule of thumb, 50% of the nitrogen excreted is in the dung and 50% is in the urine. The default emission factors for direct N_2O emissions from Manure Management are provided in the following table.

Bamyan, Afghanistan ©Mohammad Ayub Alavi

Table 246 Exemplary calculation of methane and nitrous oxide emissions for cattle for 2017 applying TIER 1 approach for 3.B Manure management

Parameter	Parameter description	Unit	Formula (as used in Excel)	Parameter Source	Comment	Dairy cattle	Non-dairy cattle
L	Livestock (# of animals)	#	-	NSIA & FAO		3,578,531	1,655,869
TAM (W)	Typical Animal Mass (average) (also TAM)	kg	-	Perspectives of the Animal Genetic Resources Development and Conservation		233.75	200.00
MS_1	Manure System - Pasture/Range/Paddock	%		FAO (2018) B. Manure uses: FAO - Nitrogen inputs to agricultural soils from livestock manure: Integrated crop management VOL.24 – 2018 http://www.fao.org/3/I8153EN/i8153en.pdf		50%	45%
MS_2	Manure System - Daily Spread	%				19%	20%
MS_3	Manure System - Solid Storage	%				10%	10%
MS_4	Manure System - Dry Lot	%				NO	4%
MS_5	Manure System - Liquid/Slurry	%				1%	1%
MS_6	Manure System - Burned for fuel	%				20%	20%
MS_7	Manure System - Anaerobic Lagoon	%				NO	0%
MS_8	Manure System - other AWMS	%				NO	0%
	Check Total MS					*100%*	0%
GE	Gross Energy Intake (average)	MJ/day	{[(Nem + NEa +NEl +NEw + NEp) / REM] + [Neg / REG]} / (DE / 100)	Equation 10.16	see sheet 3A_Enteric_Tier2	143.78	177.26
DE	Digestible Energy	%	-	Table 10.2, Chap. 10 (10.2.2), Vol. 4, 2006 IPCC Guidelines, page 10.14		55%	55%
ASH	Ash Content of the Manure	%	-	Equation 10.24; Vol. 4, Chap. 10 (10.4.2); 2006 IPCC GL; page 10.42		0.08	0.08
VS	Volatile Solid Daily Excretion	kg-dm/day	GE x (1-(DE / 100) + (1 -(UE * GE)) x (1-(ASH/18.45))			148.10	182.58
Bo	CH_4 Producing Potential	m^3CH_4/kg VS	-			0.13	0.13
CH_4 emissions							
EF_{CH4}	EF	kg CH_4/head/yr	-	Table 10.14 - Default for Asia, Vol. 4, Chap. 10; 2006 IPCC GL	Asia: 18°	16	1
CH_4 Emi	CH_4 Emissions	Gg CH_4	L x EF_{CH4} x 10^-6	Equation 10.22; Vol. 4, Chap. 10 (10.4.1); 2006 IPCC GL; p. 10.37		57.26	1.66
M	*Method*	-	-	-		*T1*	*T1*
EF used	*EF used*	-	-	-		*D*	*D*
Direct N_2O emissions							

Parameter	Parameter description	Unit	Formula (as used in Excel)	Parameter Source	Comment	Dairy cattle	Non-dairy cattle
Nrate(T)	N excretion rate	kg N /head/day	-	Table 10.19, Vol. 4, Chap. 10 (10.5.2); 2006 IPCC GL; page 10.59		0.47	0.34
Nex(T)	Annual N excretion per head	kg N animal-1 year-1	Nrate(T)*TAM*10^-3*365	Equation 10.30, Vol. 4, Chap. 10 (10.5.2); 2006 IPCC GL, p. 10.54		40.10	24.82
$NE_{MMS\ 1}$	Nitrogen Excretion Pasture/Range/Paddock	kg N/year	N_TxNex_TxMS1	-		71,749,211	64,574,290
$NE_{MMS\ 2}$	Nitrogen Excretion - Daily Spread	kg N/year	N_TxNex_TxMS2	-		27,264,700	28,699,684
$NE_{MMS\ 3}$	Nitrogen Excretion - Solid Storage	kg N/year	N_TxNex_TxMS3	-		14,349,842	14,349,842
$NE_{MMS\ 4}$	Nitrogen Excretion - Dry Lot	kg N/year	N_TxNex_TxMS4	-		0	5,739,937
$NE_{MMS\ 5}$	Nitrogen Excretion - Liquid/Slurry System	kg N/year	N_TxNex_TxMS5	-		1,434,984	1,434,984
$NE_{MMS\ 6}$	Nitrogen Excretion - Burned for fuel	kg N/year	N_TxNex_TxMS7	-		28,699,684	28,699,684
$NE_{MMS\ 7}$	Nitrogen Excretion - Anaerobic Lagoon	kg N/year	N_TxNex_TxMS8	-		0	0
$NE_{MMS\ 8}$	Nitrogen Excretion - other AWMS	kg N/year	N_TxNex_TxMS9	-		0	0
$EF_{N2O\ MMS\ 1}$	emission factors for direct N_2O Emi from Pasture Range & Paddock	kg N_2O-N (kg Nitrogen excreted)-1	-	Table 10.21, Vol. 4, Chap. 10 (10.5.3); 2006 IPCC GL; page 10.62		NA	NA
$EF_{N2O\ MMS\ 2}$	emission factors for direct N_2O Emi from Daily Spread	kg N_2O-N (kg Nitrogen excreted)-1	-	Table 10.21, Vol. 4, Chap. 10 (10.5.3); 2006 IPCC GL; page 10.62		0	0
$EF_{N2O\ MMS\ 3}$	emission factors for direct N_2O Emi from Solid Storage	kg N_2O-N (kg Nitrogen excreted)-1	-	Table 10.21, Vol. 4, Chap. 10 (10.5.3); 2006 IPCC GL; page 10.62		0.005	0.005
$EF_{N2O\ MMS\ 4}$	emission factors for direct N_2O Emi from Dry Lot	kg N_2O-N (kg Nitrogen excreted)-1	-	Table 10.21, Vol. 4, Chap. 10 (10.5.3); 2006 IPCC GL; page 10.62		0.020	0.020
$EF_{N2O\ MMS\ 5}$	emission factors for direct N_2O Emi from Liquid/Slurry	kg N_2O-N (kg Nitrogen excreted)-1	-	Table 10.21, Vol. 4, Chap. 10 (10.5.3); 2006 IPCC GL; page 10.62		0	0
$EF_{N2O\ MMS\ 6}$	emission factors for direct N_2O Emi from Burned for fuel	kg N_2O-N (kg Nitrogen excreted)-1	-	Table 10.21, Vol. 4, Chap. 10 (10.5.3); 2006 IPCC GL; page 10.62		NA	NA
$EF_{N2O\ MMS\ 7}$	emission factors for direct N_2O Emi from Anaerobic Lagoon	kg N_2O-N (kg Nitrogen excreted)-1	-	Table 10.21, Vol. 4, Chap. 10 (10.5.3); 2006 IPCC GL; page 10.62		0	0
$EF_{N2O\ MMS\ 8}$	emission factors for direct N_2O Emi from Other AWMS	kg N_2O-N (kg Nitrogen excreted)-1	-	Table 10.21, Vol. 4, Chap. 10 (10.5.3); 2006 IPCC GL; page 10.62		NA	NA
$EMI_{N2O\ MMS\ 1}$	direct N_2O Emission from Pasture, Range & Paddock	kg N_2O-N	$NE_{MMS\ 1}$*$EF_{N2O\ MMS\ 1}$ *44/28	Equation 10.25, Vol. 4, Chap. 10 (10.5.1); 2006 IPCC GL, p. 10.54		NA	NA
$EMI_{N2O\ MMS\ 2}$	direct N_2O Emission from Daily Spread	kg N_2O-N	$NE_{MMS\ 2}$*$EF_{N2O\ MMS\ 2}$ *44/28			0.00	0.00
$EMI_{N2O\ MMS\ 3}$	direct N_2O Emission from Solid Storage	kg N_2O-N	$NE_{MMS\ 3}$*$EF_{N2O\ MMS\ 3}$ *44/28			112,748.76	112,748.76

Parameter	Parameter description	Unit	Formula (as used in Excel)	Parameter Source	Comment	Dairy cattle	Non-dairy cattle
$EMI_{N2O\ MMS\ 4}$	direct N_2O Emission from Dry Lot	kg N_2O-N	$NE_{MMS\ 4}$*$EF_{N2O\ MMS\ 4}$ *44/28			0.00	180,398.02
$EMI_{N2O\ MMS\ 5}$	direct N_2O Emission from Liquid/Slurry	kg N_2O-N	$NE_{MMS\ 5}$*$EF_{N2O\ MMS\ 5}$ *44/28			0.00	0.00
$EMI_{N2O\ MMS\ 6}$	direct N_2O Emission from Burned for fuel	kg N_2O-N	$NE_{MMS\ 6}$*$EF_{N2O\ MMS\ 6}$ *44/28			NA	NA
$EMI_{N2O\ MMS\ 7}$	direct N_2O Emission from Anaerobic Lagoon	kg N_2O-N	$NE_{MMS\ 7}$*$EF_{N2O\ MMS\ 7}$ *44/28			0.00	0.00
$EMI_{N2O\ MMS\ 8}$	direct N_2O Emission from Other AWMS	kg N_2O-N	$NE_{MMS\ 8}$*$EF_{N2O\ MMS\ 8}$ *44/28			NA	NA
$N_2O_{D(mm)}$	Direct N_2O emissions	kg N_2O-N	sum ($EMI_{N2O\ MMS\ 1}$: $EMI_{N2O\ MMS\ 8}$) x 10^-6			112,75	0.293
M	*Method*	-	-	-		*T1*	*T1*
EF used	*EF used*	-	-	-		*D*	*D*
Indirect N_2O emissions							
$Frac_{gas1}$	N-NH_3 and N-NOx Losses - Pasture Range & Paddock	%	-	Table 10.22, Vol. 4, Chap. 10 (10.5.4); 2006 IPCC GL; page 10.65		*NA*	*NA*
$Frac_{gas2}$	N-NH_3 and N-NOx Losses - Daily Spread	%	-	Table 10.22, Vol. 4, Chap. 10 (10.5.4); 2006 IPCC GL; page 10.65		7%	*NA*
$Frac_{gas3}$	N-NH_3 and N-NOx Losses - Solid Storage	%	-	Table 10.22, Vol. 4, Chap. 10 (10.5.4); 2006 IPCC GL; page 10.65		30%	*45%*
$Frac_{gas4}$	N-NH_3 and N-NOx Losses - Dry Lot	%	-	Table 10.22, Vol. 4, Chap. 10 (10.5.4); 2006 IPCC GL; page 10.65		*20%*	*30%*
$Frac_{gas5}$	N-NH_3 and N-NOx Losses - Liquid/Slurry	%	-	Table 10.22, Vol. 4, Chap. 10 (10.5.4); 2006 IPCC GL; page 10.65		*40%*	*NA*
$Frac_{gas6}$	N-NH_3 and N-NOx Losses - Burned for fuel	%	-	Table 10.22, Vol. 4, Chap. 10 (10.5.4); 2006 IPCC GL; page 10.65		*NA*	*NA*
$Frac_{gas7}$	N-NH_3 and N-NOx Losses - Anaerobic Lagoon	%	-	Table 10.22, Vol. 4, Chap. 10 (10.5.4); 2006 IPCC GL; page 10.65		*35%*	*NA*
$Frac_{gas8}$	N-NH_3 and N-NOx Losses - Other AWMS	%	-	Table 10.22, Vol. 4, Chap. 10 (10.5.4); 2006 IPCC GL; page 10.65		*NA*	*NA*
$N_{volatilization\text{-}MMS\ 1}$	N volatilization - Pasture Range & Paddock	kg N	$NE_{MMS\ 1}$ x ($Frac_{gas\ mms\ 1}$ / 100)	Equation 10.26 IPCC 2006, Vol. 4, Chap. 10 (10.5.1); 2006 IPCC GL, p. 10.54		NA	NA
$N_{volatilization\text{-}MMS\ 2}$	N volatilization - Daily Spread	kg N	$NE_{MMS\ 2}$ x ($Frac_{gas\ mms\ 2}$ / 100)			19,085.29	NA
$N_{volatilization\text{-}MMS\ 3}$	N volatilization - Solid storage	kg N	$NE_{MMS\ 3}$ x ($Frac_{gas\ mms\ 3}$ / 100)			43,049.53	64,574.29
$N_{volatilization\text{-}MMS\ 4}$	N volatilization - Dry Lot	kg N	$NE_{MMS\ 4}$ x ($Frac_{gas\ mms\ 4}$ / 100)			0.00	17,219.81
$N_{volatilization\text{-}MMS\ 5}$	N volatilization - Liquid/Slurry	kg N	$NE_{MMS\ 5}$ x ($Frac_{gas\ mms\ 5}$ / 100)			5,739.94	NA

Parameter	Parameter description	Unit	Formula (as used in Excel)	Parameter Source	Comment	Dairy cattle	Non-dairy cattle
$N_{volatilization\text{-}MMS\ 6}$	N volatilization - Burned for fuel	kg N	$NE_{MMS\ 6}$ x ($Frac_{gas\ mms\ 6}$ / 100)			NA	NA
$N_{volatilization\text{-}MMS\ 7}$	N volatilization - Anaerobic	kg N	$NE_{MMS\ 7}$ x ($Frac_{gas\ mms\ 7}$ / 100)			0.00	NA
$N_{volatilization\text{-}MMS\ 8}$	N volatilization - Other AWMS	kg N	$NE_{MMS\ 8}$ x ($Frac_{gas\ mms\ 8}$ / 100)			NA	NA
EF_4	EF for N_2O emissions from atmospheric deposition of N on soils and water surfaces	kg N_2O-N (kg NH3-N + NOx-N volatilised)-1	-	Table 10.22, Vol. 4, Chap. 10 (10.5.4); 2006 IPCC GL; page 10.65		0.01	0.01
$EMI_{in\text{-}N2O\ MMS\ 1}$	indirect N_2O emission from Pasture, Range & Paddock	kg N_2O	$N_{volatilization\ MS\ 1}$ x EF_4 / $_{10)}$ x 44/28	Equation 10.27 IPCC 2006, Vol. 4, Chap. 10 (10.5.1); 2006 IPCC GL, p. 10.56		NA	NA
$EMI_{in\text{-}N2O\ MMS\ 2}$	indirect N_2O emissions due to volatilization of N from Daily Spread	kg N_2O	$N_{volatilization\ MS\ 2}$ x EF_4 / $_{10)}$ x 44/28			299.91	NA
$EMI_{in\text{-}N2O\ MMS\ 3}$	indirect N_2O emissions due to volatilization of N from Solid Storage	kg N_2O	$N_{volatilization\ MS\ 3}$ x EF_4 / $_{10)}$ x 44/28			676.49	1,014.74
$EM_{in\text{-}lN2O\ MMS\ 4}$	indirect N_2O emissions due to volatilization of N from Dry Lot	kg N_2O	$N_{volatilization\ MS\ 4}$ x EF_4 / $_{10)}$ x 44/28			0.00	270.60
$EMI_{in\text{-}N2O\ MMS\ 5}$	indirect N_2O emissions due to volatilization of N from Liquid/Slurry	kg N_2O	$N_{volatilization\ MS\ 5}$ x EF_4 / $_{10)}$ x 44/28			90.20	NA
$EMI_{in\text{-}N2O\ MMS\ 6}$	indirect N_2O emissions due to volatilization of N from Burned for fuel	kg N_2O	$N_{volatilization\ MS\ 6}$ x EF_4 / $_{10)}$ x 44/28			NA	NA
$EMI_{in\text{-}N2O\ MMS\ 7}$	indirect N_2O Emissions due to volatilization of N from Anaerobic Lagoon	kg N_2O	$N_{volatilization\ MS\ 7}$ x EF_4 / $_{10)}$ x 44/28			0.00	NA
$EMI_{in\text{-}N2O\ MMS\ 8}$	indirect N_2O emissions due to volatilization of N from Other AWMS	kg N_2O	$N_{volatilization\ MS\ 8}$ x EF_4 / $_{10)}$ x 44/28			NA	NA
$N_2O_{G(mm)}$	indirect N_2O emissions due to volatilization of N from manure management system	Mg N_2O	sum($EMI_{in\text{-}N2O\ MMS\ 1}$: $EMI_{in\text{-}N2O\ MMS\ 8}$) x 10^-6			0.001	0.001
M	*Method*	-	-	-		*T1*	*T1*
EF used	*EF used*	-	-	-		*D*	*D*

5.3.3 Uncertainties and time-series consistency for IPCC sub-category 3.B Manure management

The uncertainties for activity data and emission factors used for IPCC category 3.B *Manure management* are presented in the following table.

Table 247 Uncertainty for IPCC sub-category 3.B Manure management.

Uncertainty	CH_4	N_2O	N_2O	Reference
				2006 IPCC GL, Vol. 4, Chap. 10
Activity data: Livestock	20%	20%	20%	Chapter 10.2.3
Activity data: Manure Management System Usage	38%	38%	38%	Chapter 10.4.4
Emission factor	30%			Chapter 10.4.4
Emission factor (direct emission)		250%		Chapter 10.4.4
Emission factor (indirect emission)			50%	Chapter 10.4.4
Combined Uncertainty	**52%**	254%	502%	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

5.3.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of livestock data (statistical yearbook and FAOstat- Live Animals),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources: national statistic (NSIA, CountryStat, Agricultural Census 2003) and international statistics (FAO)

All national and international data are compared and discussed with national experts from Ministry of Agriculture Irrigation and Livestock (MAIL), National Statistics and Information Authority (NSIA), National Protection Agency (NEPA), Independent Directorate of Local Governance (IDLG), Municipality of Kabul, and University of Kabul and Kabul Polytechnic University.

See also Chapter 5.2.4

⇒ discussion of manure management systems with national experts from Ministry of Agriculture Irrigation and Livestock (MAIL), National Statistics and Information Authority (NSIA), National Protection Agency (NEPA), Independent Directorate of Local Governance (IDLG), Municipality of Kabul, and University of Kabul and Kabul Polytechnic University.

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

5.3.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category 3.B *Manure management*.

Table 248 Recalculations done since SNC in IPCC sub-category 3.B *Manure management*

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
3.B	application of 2006 IPCC Guidelines	method	Comparability
3.B	use of CH_4 default emission factor of 2006 IPCC Guidelines	EF	Comparability
3.B	use of N_2O default emission factor (direct emission) of 2006 IPCC Guidelines	EF	Comparability
3.B	use of N_2O default emission factor (indirect emission) of 2006 IPCC Guidelines	EF	Comparability

5.3.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 249 Planned improvements for IPCC sub-category 3.B *Manure management*

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.A.1	Correction of technical mistakes in calculation	AD EF	Completeness	high
3.A. 3.B. 3.D.	Survey and/or research on characteristics of Livestock Husbandry and Management Practice with consideration of regional and district as well urban and rural diversity • characteristics of Livestock Husbandry: o breed, o age distribution, o weight • characteristics of manure management practice: o stall / housed o pasture/range/paddock (flat/hilly) o grazing large areas (flat/hilly) o daily spread o solid storage o dry lot o liquid/slurry with/without natural crust cover o uncovered anaerobic lagoon o pit storage below animal confinements o anaerobic digester o burned for fuel o cattle and swine deep bedding o composting o aerobic treatment • nitrogen excretion	AD	Accuracy Consistency Comparability Transparency	high

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.A. 3.B.	Manure management by temperature for sheep, goats, camels, horses, mules, and asses, and poultry	AD	Accuracy Comparability Transparency	medium
3.B	Estimation of methane (CH_4) and nitrous oxide (N_2O) emissions applying TIER 2 approach as some sub-categories are key categories	meth od	Transparency Comparability	high
3.A.1.j 3.B. 3.D	Survey and/or research on Livestock which is not included in current statistics: e.g. buffalo, llamas, alpacas, fur bearing animals	AD	Completeness	High
3.B 3.D	Survey and/or research on Livestock split of poultry: • broiler chickens, layer hens, poultry (free range) • turkeys, • ducks, • geese	AD	Accuracy Consistency Comparability Transparency	High
3.B	Survey and/or research on VS excretion rates		Accuracy	medium

5.4 Rice cultivation (IPCC category 3.C)

This section describes the estimation of methane emissions resulting from rice cultivation. As described in the *2006 IPCC Guidelines Volume 4, Chapter 5.5* anaerobic decomposition of organic material in flooded rice fields produces methane (CH_4), which escapes to the atmosphere primarily by transport through the rice plants. 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 cultivation period, and organic and inorganic soil amendments. Soil type, temperature, and rice cultivar also affect CH_4 emissions.

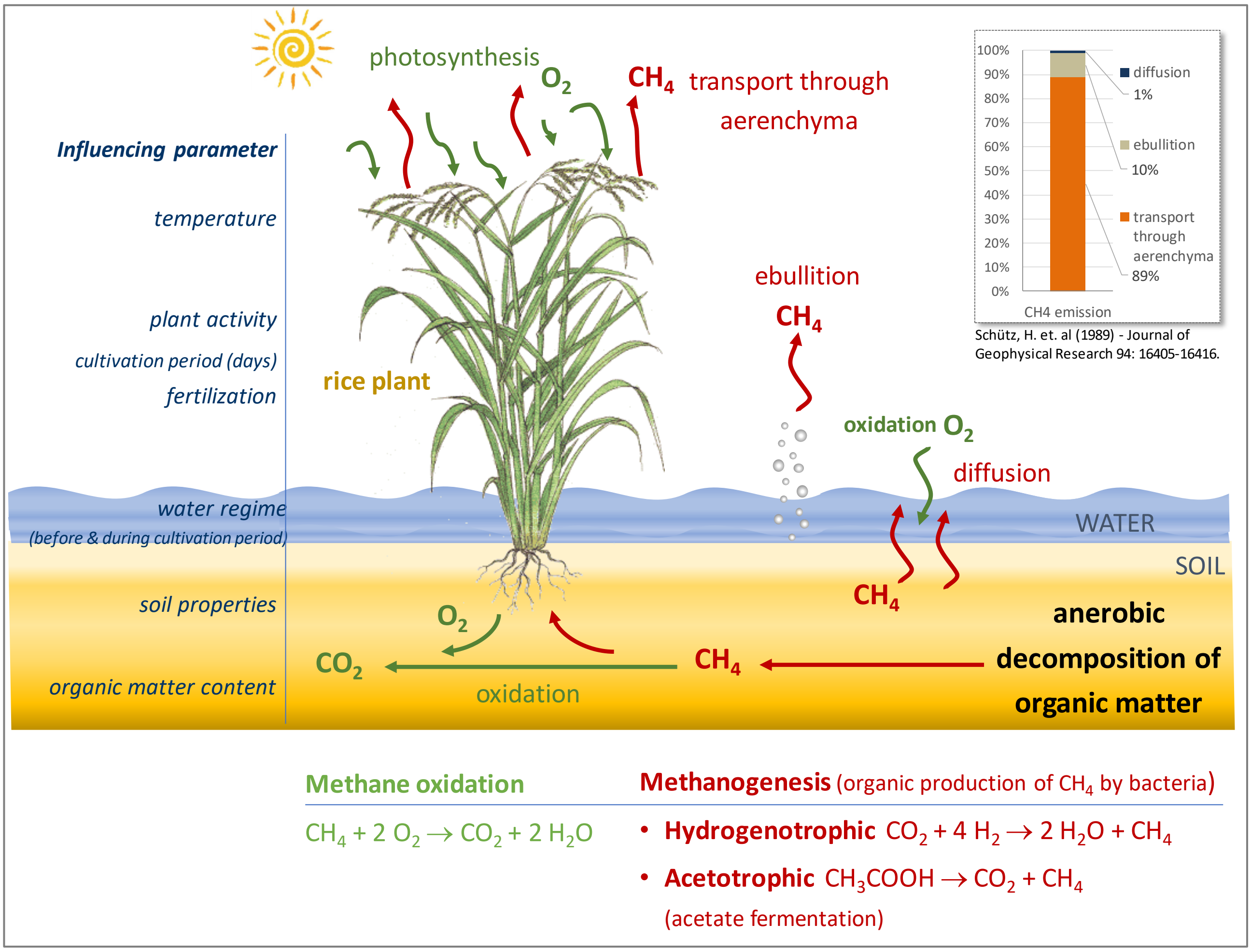


Figure 155 Schematic overview of CH_4 emissions from flooded rice fields

After wheat, rice is the most important staple crop in Afghanistan. Most of the rice is grown in the northern, eastern, and western regions of Afghanistan, depending on water availability. The top producing provinces, which together account for 91% of the country's rice production, are Baghlan, Kunduz, Takhar, Laghman, Herat, Nangarhar, Balkh, and Kunar.

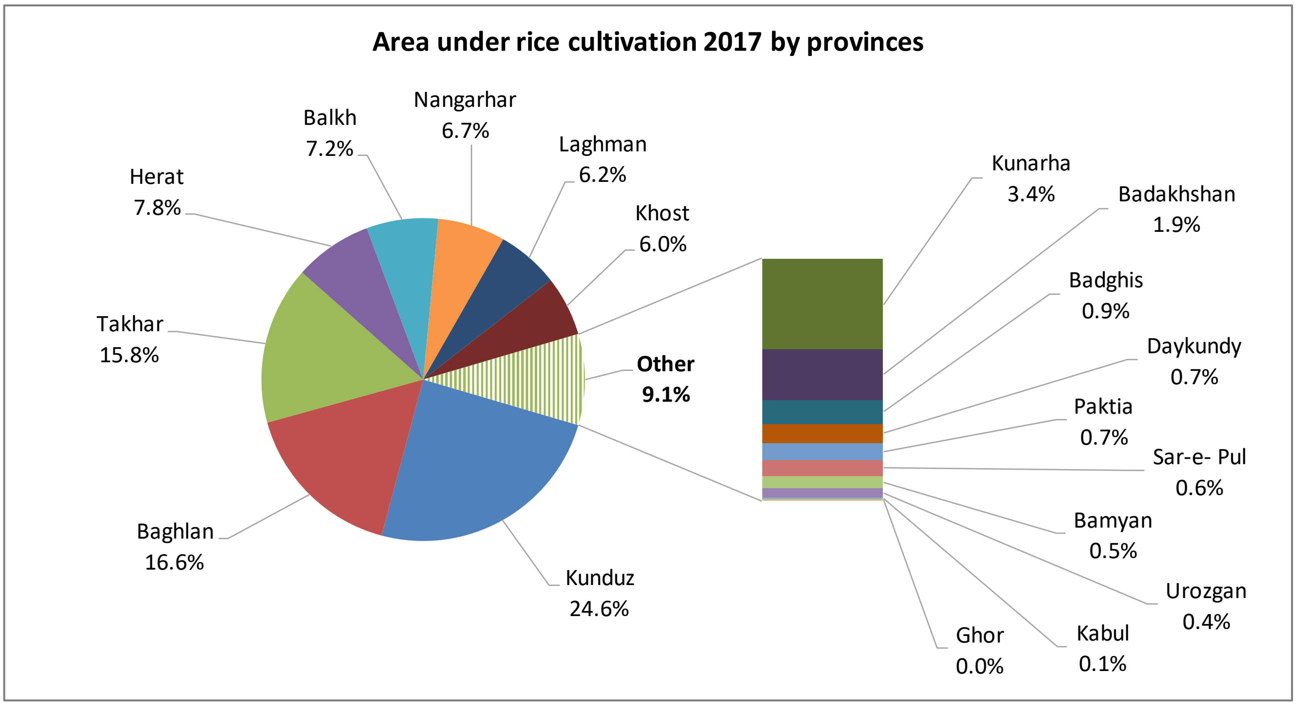


Figure 156 **Area under rice cultivation by provinces in 2017**

Source: NSIA (2019): Afghanistan Statistical Yearbook 2017-2018. Table 8-7:Rice, Barley, Maize Area and Production by Province. Kabul

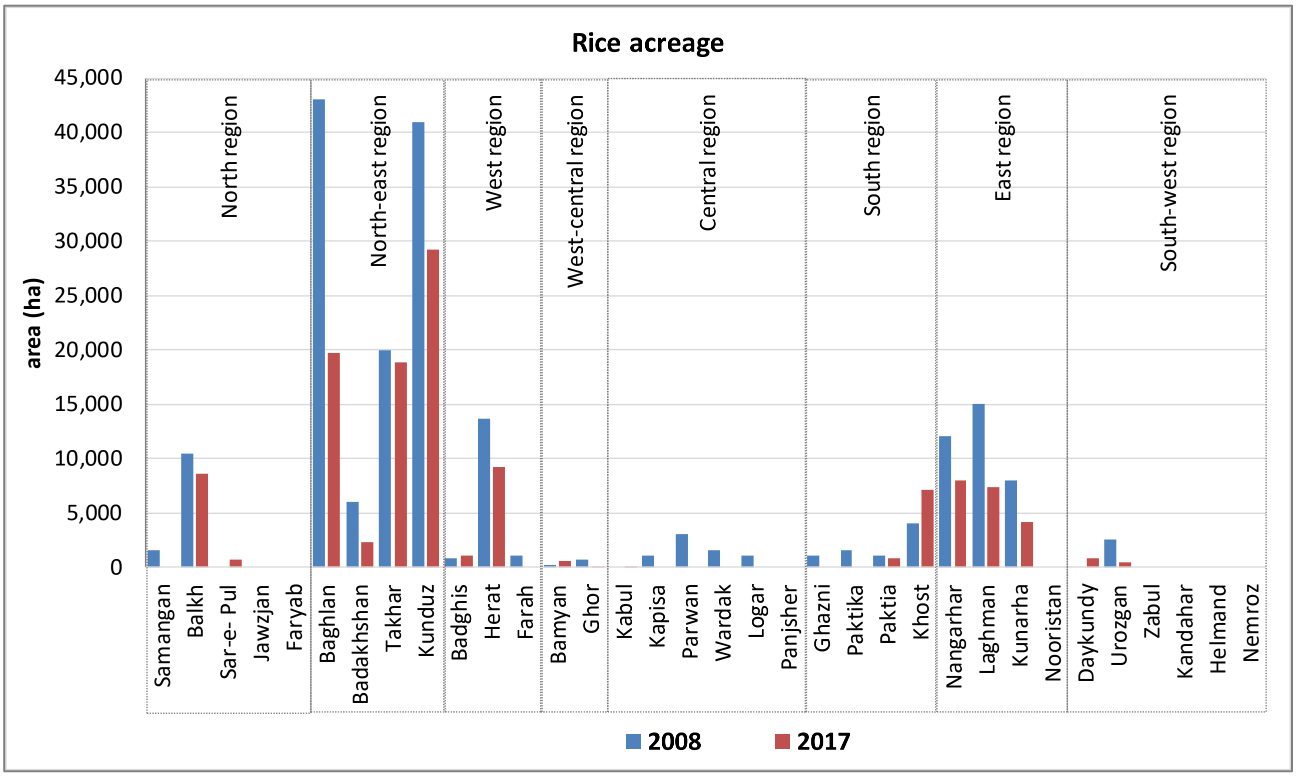


Figure 157 **Area under rice cultivation by provinces in 2008 and 2017**

Source: NSIA: Statistical Yearbook 2008/2009; Afghanistan Statistical Yearbook 2017-2018. Table 8-7:Rice, Barley, Maize Area and Production by Province. Kabul

5.4.1 Source category description

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.C	**Rice Cultivation**						
3.C.1	Irrigated	NA	-	✓	-	NA	-
3.C.1.i	Continuously flooded	NA	-	✓	LA 1990, LA 2017, TA	NA	-
3.C.1.ii	Intermittently flooded Single aeration	NA	-	IE	-	NA	-
3.C.1.iii	Intermittently flooded Multiple aeration	NA	-	IE	-	NA	-
3.C.2	Rainfed	NA	-	✓	-	NA	-
3.C.2.i	Flood prone	NA	-	✓	-	NA	-
3.C.2.ii	Drought prone	NA	-	✓	-	NA	-
3.C.3	Deep water	NA	-	✓	-	NA	-
3.C.3.i	Water depth 50–100 cm	NA	-	✓	-	NA	-
3.C.3.ii	Water depth > 100 cm	NA	-	✓	-	NA	-
3.C.4	Other (please specify)	NA	-	✓	-	NA	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment

In 2017, this source category was responsible for 14% of agricultural methane emissions and for 8.6% of the total methane emissions estimated for Afghanistan. It represented 9.4% of the GHG emissions from the agriculture sector and 4% of the total GHG emissions in CO_2eq (excluding LULUCF).

In the period 1990 – 2017 the CH_4 emissions increased by 25.7%. In the period 2005 – 2017 the CH_4 emissions increased by 37.5% mainly due to increased area under rice cultivation.

The significant drop in the period 1999 – 2001 is mainly due to the war where many farmers were not able to work on their farms. After the war the cultivation of the rice fields started but it took time to rehabilitate the rice fields. Traditional farming, labor shortage, difficulties with land leveling, pest and diseases are some reasons for the slow rehabilitation. Furthermore, shifting to rice cultivation in upstream areas has led to water scarcity in downstream parts of numerous canal systems, exacerbating tensions between communities and canals and at river basin level.[160]

An overview of the methane emissions resulting IPCC category 3.C Rice Cultivation is provided in the following figure and table.

[160] Aga Khan Foundation Foundation-Afghanistan (AKF)(NN): System of Rice Intensification in Afghanistan. Participatory Management of Irrigation Systems Program (PMIS). Kabul.

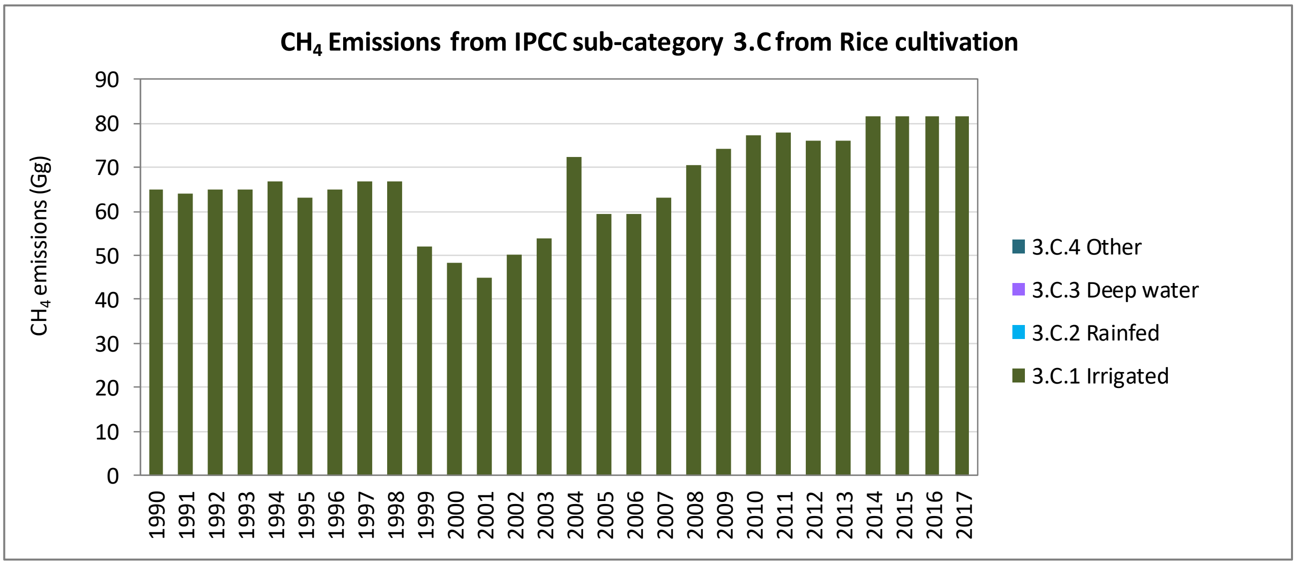


Figure 158 **CH_4 Emissions from IPCC sub-category 3.C Rice Cultivation**

Paghman valley, Kabul ©Mohammad Monib Noori

Table 250 CH_4 Emissions from IPCC category 3.C Rice Cultivation by sub-categories

CH_4 emissions	3.C		3.C.1	3.C.1.i	3.C.1.ii	3.C.1.iii	3.C.2	3.C.2.i	3.C.2.ii	3.C.3	3.C.3.i	3.C.3.ii	3.C.4
	Rice Cultivation		Irrigated	Continuously flooded	Intermittently flooded Single aeration	Intermittently flooded Multiple aeration	Rainfed	Flood prone	Drought prone	Deep water	Water depth 50–100 cm	Water depth > 100 cm	Other
	Gg $_{CO2\ equivalent}$	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**
1990	1,623.18	64.93	64.93	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
1991	1,604.63	64.19	64.19	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
1992	1,623.18	64.93	64.93	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
1993	1,623.18	64.93	64.93	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
1994	1,669.55	66.78	66.78	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
1995	1,576.80	63.07	63.07	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
1996	1,623.18	64.93	64.93	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
1997	1,669.55	66.78	66.78	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
1998	1,669.55	66.78	66.78	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
1999	1,298.54	51.94	51.94	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2000	1,205.79	48.23	48.23	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2001	1,122.31	44.89	44.89	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2002	1,252.17	50.09	50.09	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2003	1,344.92	53.80	53.80	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2004	1,808.68	72.35	72.35	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2005	1,484.05	59.36	59.36	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2006	1,484.05	59.36	59.36	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2007	1,576.80	63.07	63.07	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2008	1,762.31	70.49	70.49	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2009	1,855.06	74.20	74.20	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO

CH_4 emissions	3.C		3.C.1	3.C.1.i	3.C.1.ii	3.C.1.iii	3.C.2	3.C.2.i	3.C.2.ii	3.C.3	3.C.3.i	3.C.3.ii	3.C.4
	Rice Cultivation		Irrigated	Continuously flooded	Intermittently flooded Single aeration	Intermittently flooded Multiple aeration	Rainfed	Flood prone	Drought prone	Deep water	Water depth 50–100 cm	Water depth > 100 cm	Other
	Gg CO2 equivalent	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**
2010	1,929.26	77.17	77.17	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2011	1,947.81	77.91	77.91	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2012	1,901.44	76.06	76.06	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2013	1,901.44	76.06	76.06	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2014	2,040.57	81.62	81.62	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2015	2,040.57	81.62	81.62	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2016	2,040.57	81.62	81.62	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
2017	2,040.57	81.62	81.62	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
Trend													
1990 - 2017	*25.7%*	*25.7%*	*25.7%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2017	*37.5%*	*37.5%*	*37.5%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2012 - 2017	*7.3%*	*7.3%*	*7.3%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2016 - 2017	*0.00%*	*0.00%*	*0.0%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

5.4.2 Methodological issues

5.4.2.1 Choice of methods

CH_4 emissions are estimated by multiplying daily emission factors by cultivation period of rice and annual harvested areas, using the basic equation provided in the 2006 IPCC Guidelines, Vol. 4, Chapter 5.5 (equation 5.1). In its most simple form, this equation is implemented using national activity data (i.e., national average cultivation period of rice and area harvested) and a single emission factor. However, the natural conditions and agricultural management of rice production may be highly variable within a country. It is good practice to account for this variability by disaggregating national total harvested area into sub-units.

TIER 1 approach

For estimating the CH_4 emissions from rice cultivation the 2006 IPCC Guidelines Tier 1 approach[161] has been applied.

Equation 5.1: CH_4 emissions from rice cultivation

$$\boldsymbol{Emissions_{CH4}} = \sum_{i,j,k} \boldsymbol{EF_{i,j,k}} \times \boldsymbol{t_{i,j,k}} \times \boldsymbol{A_{i,j,k}} \times \boldsymbol{10^{-6}}$$

Where:

$Emissions_{CH4}$	= annual methane emissions from rice cultivation (Gg CH_4)
$EF_{i,j,k}$	= daily emission factor for i, j, and k conditions (kg CH_4 ha-1 day-1)
$t_{i,j,k}$	= cultivation period of rice for i, j, and k conditions, day
$A_{i,j,k}$	= annual harvested area of rice for i, j, and k conditions, ha $^{yr-1}$
i	= represent different ecosystems
j	= represent different water regimes
k	= represent different type and amount of organic amendments, and other conditions under which CH_4 emissions from rice may vary

Tier 1 was used as no country specific emission factors (CS EF) and relevant country/region specific scaling factors could not be developed. At this stage a disaggregation of the annual harvest area of rice in the three baseline water regimes including irrigated, rainfed, and upland could be done. Therefore, a daily adjusted daily emission factor for total harvested area under rice cultivation was prepared.

Equation 5.2: Adjusted daily emission factor

$$\boldsymbol{EF_i = EF_c \times SF_w \times SF_p \times SF_o \times EF_{s,r}}$$

Where:

EF_i	= adjusted daily emission factor for (a particular) harvested area
EF_c	= baseline emission factor for continuously flooded fields without organic amendments
SF_w	= scaling factor to account for the differences in water regime during the cultivation period
SF_p	= scaling factor to account for the differences in water regime in the pre-season before the cultivation period
SF_o	= scaling factor should vary for both type and amount of organic amendment applied
$SF_{s,r}$	= scaling factor for soil type, rice cultivar

[161] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 5 Cropland, sub-chap 5.5.1 Choice of method

5.4.2.2 Choice of activity data

The agricultural data used and presented in this inventory are taken from national and international sources:

- Afghanistan National Livestock Census[127]
- Afghanistan Statistical yearbook[128]
- CountrySTAT[129]
- FAO agricultural data base[130]

The original data provider for the national and international database is the Ministry of Agriculture Irrigation and Livestock (MAIL).

The annual harvested area under rice is presented in the following figure and table. In 2017 amounted the rice acreage about 109,452 ha, while the area under rice cultivation was in 1990 about 175,000 ha and 2005 about 160,000 ha. This decrease in area of cultivation was due to weeds, diseases, and pests as major constraints but also in (professional) labor shortage, difficulties with land leveling, water scarcity in downstream etc.

According to Kakar, K et al (2019)[162] starts the planting period for rice cultivation from March–April, transplanting from May–June, and harvesting at the end of October, but this varies among cultivars and regions. Rice is planted mostly under irrigated conditions. The rice is commonly grown at 1000–3000 feet above sea level, though it is sporadically cultivated at >6000 feet elevation. In the East rice is grown immediately after wheat as a transplanted crop.[163] In Herat, it is either transplanted or broadcasted at very high seed rates. Transplanted rice is also an important crop in Baghlan and in the Jalalabad area during the second season. Farmers in the Herat province usually apply fertilizers to rice, while in other provinces the number of farmers who apply fertilizers to rice is low.

A disaggregation of the annual harvest area of rice for at least three baseline water regimes including irrigated, rainfed, and upland was not possible for this submission.

[162] Kakar, K; Xuan, T. D.; Haqani, M. I; Rayee, R.; Khan Wafa, I; Abdiani, S. & Tran, H.-D. (2019): Current Situation and Sustainable Development of Rice Cultivation and Production in Afghanistan. In: Agriculture 2019, 9, 49. MDPI. Basel. https://doi.org/10.3390/agriculture9030049.

[163] FAO (2002): Available on 18.12.2018 at: http://www.fao.org/3/Y4347E/y4347e05.htm

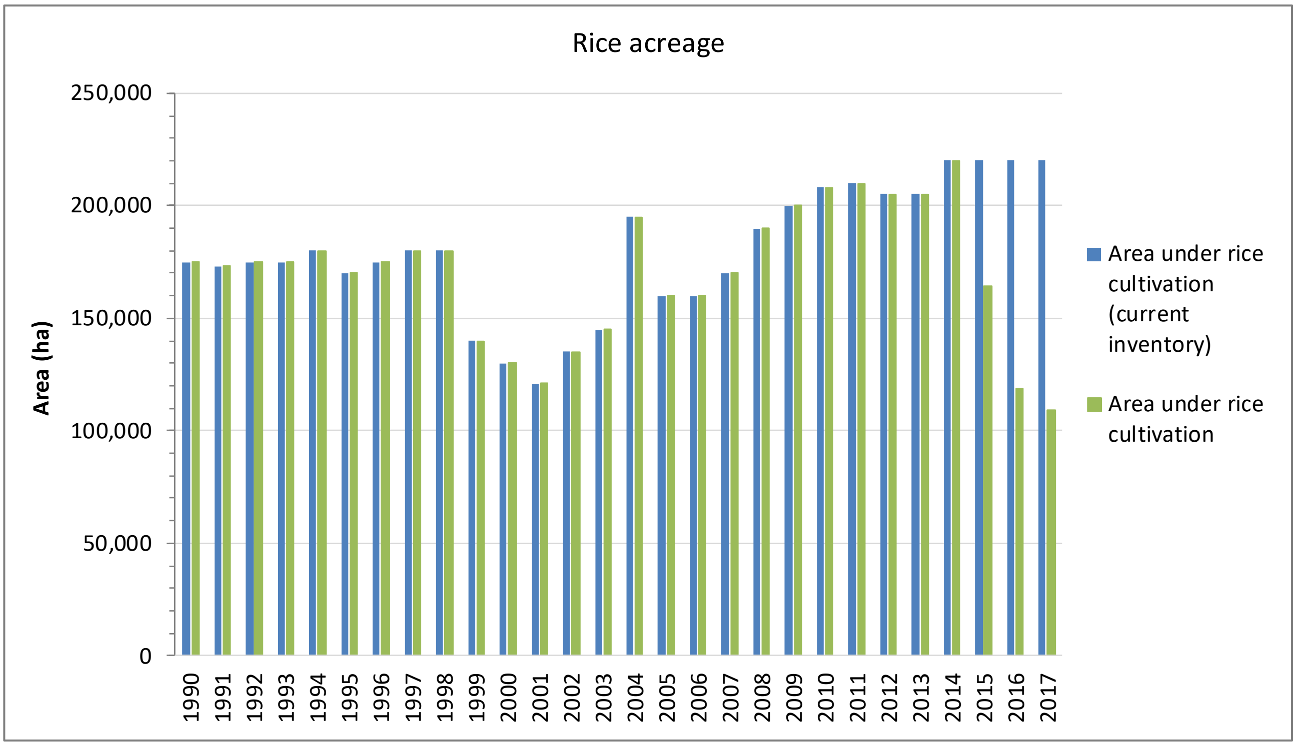


Figure 159 **Area under rice cultivation and its trend**

Table 251 Area under rice cultivation and its trend

Due to technical mistake, the activity data of the years 2015-2017 are not correctly transferred. Anyway, the correct information is already presented in this table. With the next submission a recalculation will be done.

	Arable area	*reference*	Annual Harvested area						
			Rice cultivation	*reference*	Rice cultivation			Rice cultivation (Used in current inventory)	*reference*
					irrigated	rainfed	upland		
	1000 ha		ha		ha			ha	
1990	7,650,000	FAO	175,000	FAO				175,000	FAO
1991	7,650,000		173,000					173,000	
1992	7,650,000		175,000					175,000	
1993	7,650,000		175,000					175,000	
1994	7,650,000		180,000					180,000	
1995	7,753,000	SY	170,000	SY				170,000	SY
1996	7,753,000	interpolation	175,000	interpolation				175,000	interpolation
1997	7,753,000		180,000					180,000	
1998	7,753,000		180,000					180,000	
1999	7,753,000	NSIA - Statistical yearbooks (SY)	140,000	NSIA - Statistical yearbooks (SY)				140,000	NSIA - Statistical yearbooks (SY)
2000	7,753,000		130,000					130,000	
2001	7,753,000		121,000					121,000	
2002	7,753,000		135,000					135,000	
2003	7,910,000		145,000					145,000	
2004	7,911,000		195,000					195,000	
2005	7,910,000		160,000					160,000	
2006	7,910,000		160,000					160,000	

	Arable area	*reference*	**Annual Harvested area**						
			Rice cultivation	*reference*	**Rice cultivation**			**Rice cultivation** (Used in current inventory)	*reference*
					irrigated	**rainfed**	**upland**		
	1000 ha		**ha**		**ha**			**ha**	
2007	7,910,000		170,000					170,000	
2008	7,910,000		190,000					190,000	
2009	7,910,000		200,000					200,000	
2010	7,910,000		208,000					208,000	
2011	7,910,000		210,000					210,000	
2012	7,910,000		205,000					205,000	
2013	7,845,000		205,000					205,000	
2014	7,910,000		220,000					220,000	
2015	7,910,000		164,000					220,000	p2
2016	7,829,000		119,000					220,000	p2
2017	7,829,000	p1	109,452					220,000	p2
Trend									
1990 - 2017	*2.3%*		*-37%*					*26%*	
2005 - 2017	*-1.0%*		*-32%*					*38%*	
2016 - 2017	*0.0%*		*-8%*					*0%*	
Remark: p1 – preliminary (value of 2016); p2 – preliminary (value of 2014)									

The following table shows the major local and improved rice cultivars in Afghanistan with their growth and yield characteristics. Currently no information was available regarding the use of cultivars in the different regions. Therefore, the scaling factor for the cultivar (SF_r) was set to 1.

Table 252 Principal local and improved rice cultivars in Afghanistan and their growth characteristics

Cultivars	Type	Maturity	GP	Group	Origin	DH	Paddy Yield (t/ha)
Shishambagh-14	Improved	Moderate	140	Short	India	110	8.5
Garma Ghati Japani	Improved	Moderate	130	Short	Japan	103	6.5
Zodrass	Improved	Moderate	128	short	India	103	8.2
Surkha Zerati	Local	Moderate	130	Short	India	106	5.2
Sarda Behsoodi	Local	Late	142	Short	Japan	114	5.8
Kormaki Ghati	Local	Late	142	Short	India	123	6.0
Sarda Barah	Local	Late	142	Short	India	114	4.5
Lawangi	Local	Late	142	Short	Korea	117	4.2
Garma Behsoodi	Local	Late	142	Short	Japan	124	6.0
Nezam Ghati	Local	Late	142	Short	India	125	5.5
Kunduz No. 1	Improved	Early	113	Medium	India	86	7.0
Jalalabad-14	Improved	Moderate	140	Medium	Indica	110	8.5
Manjoti	Local	Late	149	Medium	India	117	6.5
Sela Panjabi	Improved	Early	113	Long	Pakistan	88	6.8
IR 28	Improved	Early	113	Long	Philippines	91	5.8

Cultivars	Type	Maturity	GP	Group	Origin	DH	Paddy Yield (t/ha)
IR 2016	Improved	Early	113	Long	Philippines	93	5.5
IR 22	Improved	Moderate	124	Long	Philippines	101	5.5
Attai-1	Improved	Late	145	Long	Indica	115	8.0
Super Basmati	Local	Late	149	Long	India	136	7.0

Source: Kakar, K; Xuan, T. D.; Haqani, M. I; Rayee, R.; Khan Wafa, I; Abdiani, S. & Tran, H.-D. (2019): Current Situation and Sustainable Development of Rice Cultivation and Production in Afghanistan. In: Agriculture 2019, 9, 49. MDPI. Basel. https://doi.org/10.3390/agriculture9030049.

5.4.2.3 Choice of emission factors

In order to prepare the 'Adjusted daily emission factor for (a particular) harvested area' (EF_i) a default baseline emission factor and default scaling factors (SF) were taken from IPCC 2006 Guidelines and are presented in the following.

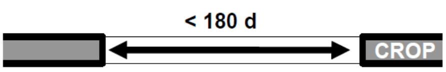
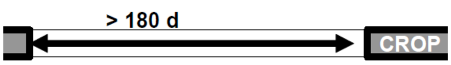
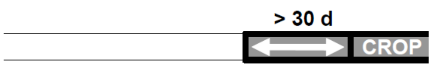
EF_c - Baseline emission factor for continuously flooded fields without organic amendments

Emission factor	Assumption	Source
1.30 kg CH_4 ha-1 d-1	assuming no flooding for less than 180 days prior to rice cultivation, and continuously flooded during rice cultivation without organic amendments	2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 5 Cropland, sub-chap 5.5.2 Choice of emission and scaling factors. Table 5.11, page 5.49

SF_w - Scaling factor to account for the differences in **water regime during** the cultivation period

Scaling factor - SFw	Assumption	Source
0.78	Assuming that the total rice acreage is • irrigated and • continuously flooded or intermittently flooded with single or multiple aeration'	2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 5 Cropland, sub-chap 5.5.2 Choice of emission and scaling factors. Table 5.12, page 5.49

SF_p - scaling factor to account for the differences in **water regime** in the **pre-season before** the cultivation period

Scaling factor - SFw	Aggregated case	Source
	Water regime prior to rice cultivation (schematic presentation showing flooded periods as shaded)	
1.22	Non flooded preseason <180 d 	2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 5 Cropland, sub-chap 5.5.2 Choice of emission and scaling factors. Table 5.13, page 5.50
	Non flooded preseason >180 d 	
	Flooded preseason (>30 d) 	

SF_o - Adjusted CH_4 emission scaling factors for organic amendments should vary for both type and amount of organic amendment applied

It is good practice to develop scaling factors that incorporate information on the type and amount of organic amendment applied (compost, farmyard manure, green manure, and rice straw). On an equal mass basis, more CH_4 is emitted from amendments containing higher amounts of easily decomposable carbon and emissions also increase as more of each organic amendment is applied.

For this submission, the practises regarding incorporation of straw before cultivation and application of organic amendment such as compost, farm yard manure or green manure were well known.

Equation 5.3: Adjusted daily emission factor[164]

$$SF_0 = \left(1 + \sum_i ROA_i \times CFOA_i\right)^{0.59}$$

Where:

SF_o = scaling factor for both type and amount of organic amendment applied

ROA_i = application rate of organic amendment i, in dry weight for straw and fresh weight for others (tonne/ha)

$CFOA_i$ = conversion factor for organic amendment i (in terms of its relative effect with respect to straw applied shortly before cultivation)

Application rate of organic amendment (ROA)	Organic amendment	Source
15 t / ha (fresh weight)	Farmyard manure	Expert judgement based on • information provided in NIR of other countries • Janza, B. et al. (2018)[165]

Conversion factor (CFOA)	Organic amendment	Source
1	Straw incorporated shortly (<30 days) before cultivation	2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 5 Cropland, sub-chap 5.5.2 Choice of emission and scaling factors. Table 5.14, page 5.49
0.29	Straw incorporated long (>30 days) before cultivation	
0.05	Compost	
0.14	Farmyard manure	
0.50	Green manure	

In the following table is presented an exemplary calculation of methane emissions for 3.C Rice Cultivation 2017 applying TIER 1 approach.

[164] 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 5 Cropland, sub-chap 5.5.2 Choice of emission and scaling factors. Table 5.13, page 5.50

[165] Janza, B.; Wellera, S.; Krausa, D.; Racelab, H. S.; Wassmanna,R.; Butterbach-Bahla, K. & Kiese, R. (2018): Greenhouse gas footprint of diversifying rice cropping systems: Impacts of water regime and organic amendments. In: Agriculture, Ecosystems and Environment 270–271 (2019) 41–54. https://doi.org/10.1016/j.agee.2018.10.011

Table 253 Exemplary calculation of methane emissions for 3.C Rice Cultivation 2017 applying TIER 1 approach for 3.C Rice Cultivation

Parameter	Parameter description	Unit	Formula (as used in Excel)	Parameter Source	Comment	Rice cultivation
A	Annual harvested area	ha	-	Statistical yearbooks, FAOSTAT		220,000
EFc	Baseline emission factor	kgCH_4/ha/day	-	Table 5.11, Vol. 4, Chap. 5 (5.5.2); 2006 IPCC GL; page 5.49		1.3
SFw	Scaling factor water management	-	-	Table 5.12, Vol. 4, Chap. 5 (5.5.2); 2006 IPCC GL; page 5.49		1
SFp	Scaling factor to account for the differences in water	-	-	Table 5.13, Vol. 4, Chap. 5 (5.5.2); 2006 IPCC GL; page 5.50		1.22
ROA	Application rate of organic amendment	t/ha (fresh weight)	-	Expert judgement based on information provided in NIR of other countries and Janza, B. et al. (2018)[165]		15
CFOA	Conversation factor for organic amendment	-	-	Table 5.14, Vol. 4, Chap. 5 (5.5.2); 2006 IPCC GL; page 5.51		0.14
Sfo	Scaling factor organic amendments	-	Sfo=(1+∑ROA x CFOA)^0,59	Equation 5.3, Vol. 4, Chap. 5 (5.5.2); 2006 IPCC GL; page 5.50		1.95
EF	Daily emission factor	kg CH_4/ha/day	Efc x SFw x SFp x Sfo	Equation 5.2, Vol. 4, Chap. 5 (5.5.1); 2006 IPCC GL; page 5.48		3.09
t	Cultivation period of rice	day	-	https://afghanag.ucdavis.edu/grain-field-crops/files/rice-overview.pdf		120
CH_4	Annual methane emissions	Gg CH_4/yr	EF x t x A x 10^-6	Equation 5.1, Vol. 4, Chap. 5 (5.5.1); 2006 IPCC GL; page 5.45		81.62

5.4.3 Uncertainties and time-series consistency for IPCC sub-category 3.C Rice Cultivation

The uncertainties for activity data and emission factors used for IPCC category 3.C Rice Cultivation are presented in the following table.

Table 254 Uncertainty for IPCC sub-category 3.C Rice Cultivation.

Uncertainty	CO_2	CH_4	N_2O	Reference
				2006 IPCC GL, Vol. 4, Chap. 5
Activity data (AD)	-	20%	-	Chapter 5.5.4
Emission factor (EF)	-	60%	-	Chapter 5.5.4
Combined Uncertainty	-	63%	-	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

5.4.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of livestock data (statistical yearbook and FAOstat- Live Animals),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources: national statistic (NSIA, CountryStat) and international statistics (FAO)

⇒ (brief) discussion of rice cultivation with national experts from Ministry of Agriculture Irrigation and Livestock (MAIL), National Statistics and Information Authority (NSIA), National Protection Agency (NEPA), Independent Directorate of Local Governance (IDLG), Municipality of Kabul, and University of Kabul and Kabul Polytechnic University.

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

5.4.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category 3.C Rice Cultivation.

Table 255 Recalculations done since SNC in IPCC sub-category 3.C Rice Cultivation

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
3.C	application of 2006 IPCC Guidelines	method	Comparability
3.C	use of CH_4 default emission factor of 2006 IPCC Guidelines	EF	Comparability Transparency Accuracy

5.4.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 256 Planned improvements for IPCC sub-category 3.C Rice Cultivation

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.C	Correction of technical mistakes in calculation	AD	Accuracy	high
3.C	Reconsideration of the used notation keys (especially IE)	AD	Transparency Accuracy	high
3.C.	Survey and/or research on characteristics of • rice ecosystem type • regional differences in rice cropping practices • general water management practices • Multiple crops	AD	Accuracy Consistency Comparability Transparency	High
3.C.	Survey and/or research on characteristics of • irrigated o continuously flooded o intermittently flooded – single aeration o intermittently flooded – multiple aeration • rainfed and deep water o regular rainfed o drought prone o deep water	AD	Accuracy Consistency Comparability Transparency	High
3.C.	Survey and/or research on characteristics of • type and amount of organic amendments: compost, farmyard manure, green manure, rice straw, etc.	AD	Accuracy Consistency Comparability Transparency	High
3.C.	Survey and/or research on characteristics of • soil type of area under rice cultivation	AD	Accuracy	medium
3.C.	Survey and/or research on characteristics of • number of rice crops grown annually • rice cultivar / most important rice cultivars grown • local definition (e.g., early rice, late rice, wet season rice, dry season rice	AD	Accuracy Consistency Comparability Transparency	High

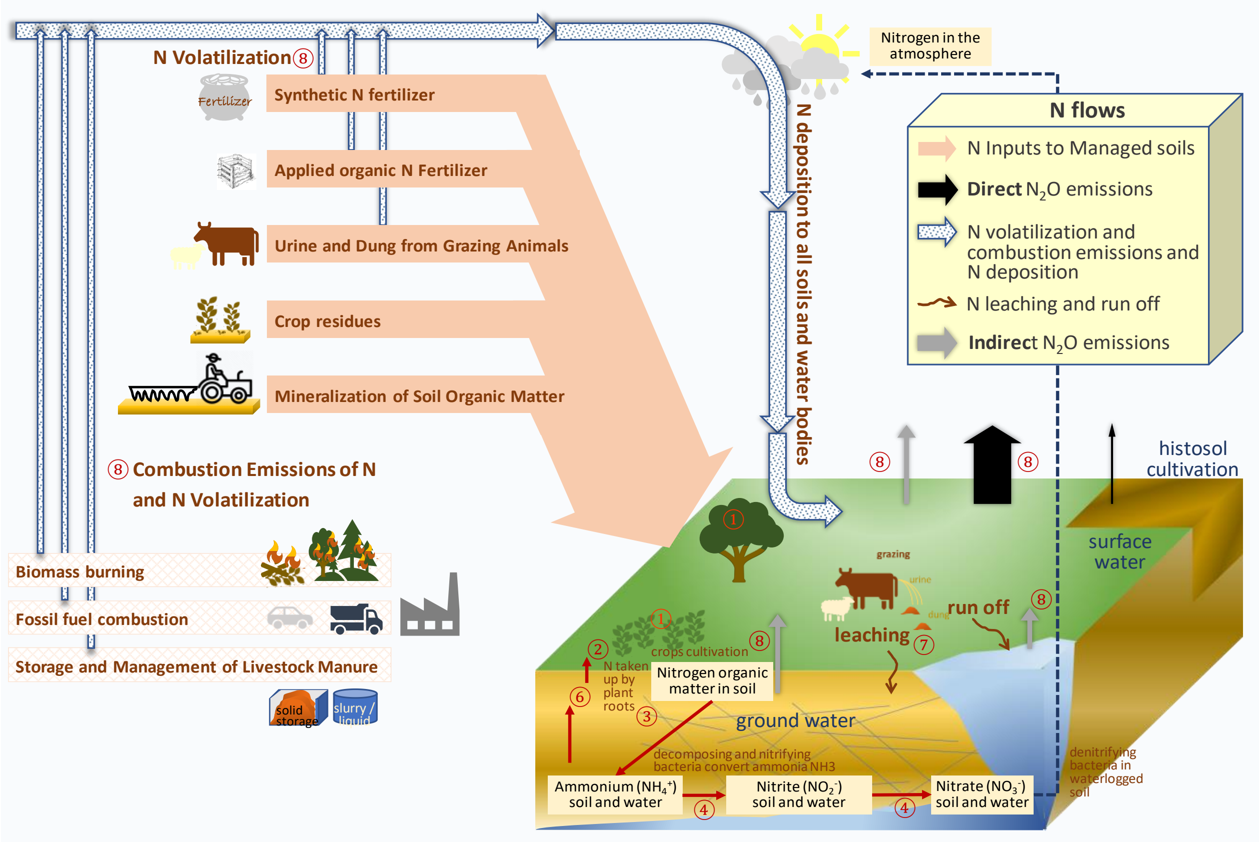
5.5 Agricultural soils (IPCC category 3.D)

This section describes the estimation of nitrous oxide emissions from managed soils due to nitrogen input, including indirect N_2O emissions from additions of N to land due to deposition and leaching. As defined in 2006 IPCC GL, Vol. 4, Chap. 1.1 managed land is land where human interventions and practices have been applied to perform production, ecological or social functions. The emissions of N_2O that result from anthropogenic N inputs or N mineralization occur through both:

- direct pathway: directly from the soils to which the N is added/released
- indirect pathways: (i) following volatilization of NH_3 and NO_x from managed soils and from fossil fuel combustion and biomass burning, and the subsequent redeposition of these gases and their products NH_4^+ and NO_3^- to soils and waters; and

  (ii) after leaching and runoff of N, mainly as NO_3^-, from managed soils.

The principal pathways are illustrated in the following figure. Direct emissions of N_2O from managed soils are estimated separately from indirect emissions, though using a common set of activity data.



The nitrogen cycle: (1) uptake of nitrogen by plants from the atmosphere: (2) uptake of ammonium and nitrate by plants from soil and water: nitrogen-fixing bacteria in humus and in root nodules of leguminous plants (3) ammonification, (4) nitrification, (5) denitrification, (6) nitrate immobilization by soil sorption, (7) nitrate leaching from the soil, (8) release of ammonia (NH3), gaseous nitrogen and nitrous oxide to the atmosphere.

Figure 160 Schematic diagram illustrating the sources and pathways of N that result in direct and indirect N_2O emissions from soils and waters

Source: After (1) 2006 IPCC Guidelines, Volume 4, Chapter 11, Figure 11.1, page 11.8. and
(2) Bednarek, A.; Szklarek, S. & Zalewski, M. (2014): Nitrogen pollution removal from areas of intensive farming—comparison of various denitrification biotechnologies. In: Ecohydrology & Hydrobiology 14 (2014) 132–141.

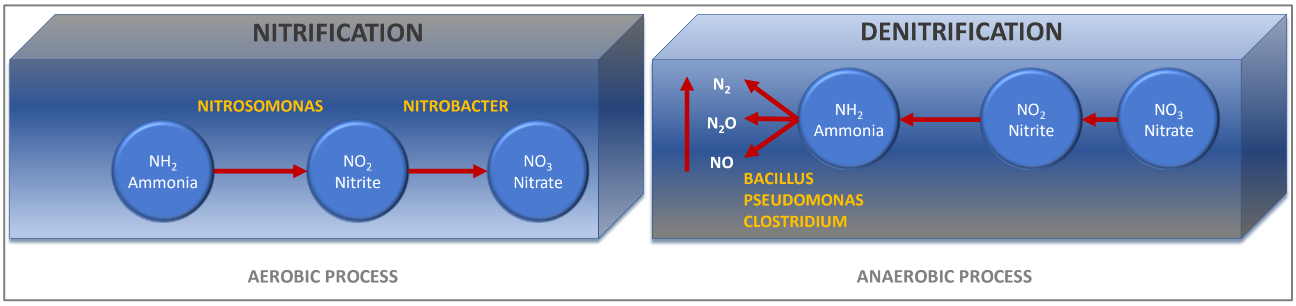


Figure 161 Nitrification and Denitrification

As described in Chapter 5.3 and in Figure 150 the N_2O emissions generated by manure in the

- system "livestock housing and holding areas" and "manure storage" are reported under the category
  ⇒ 3.B Manure management
- system 'pasture, range, and paddock' occur directly and indirectly from the soil, and are therefore reported under the category
  ⇒ 3.D.a *Direct N_2O emissions from managed soils*
  ⇒ 3.D.a.2 *Organic N fertilizers*
  ⇒ *3.D.a.2.a Animal manure applied to soils*
  ⇒ 3.D.b *IndirectN_2O Emissions from managed soils*

Beyond that further 'man-made' nitrogen applied to the soil are synthetic fertilizer application, crop residues, and mineralization of soil organic matter. Through nitrogen vitalization and combustion emissions of N from fossil fuels from all nitrogen sources a 'nitrogen stock in the atmosphere' is formed also depending of the amount and characteristics of the N-inputs.

The deposition of nitrogen (N) to soils and water bodies result from

- Nitrogen vitalization from
  - synthetic fertilizer application
  - application of organic N fertilizer
  - urine and dung from grazing animals
  - crop residues
  - mineralization of soil organic matter
- Nitrogen vitalization and combustion emission of N from
  - biomass burning
  - fossil fuel combustion
  - storage and management of livestock manure

5.5.1 Source category description

IPCC code	Description	Description	CO_2		CH_4		N_2O	
			Estimated	Key Category	estimated	Key category	estimated	Key category
3.D	**Manure Management**							
3.D.a	**Direct N_2O emissions from managed soils**							LA 1990, 2017; TA
3.D.a.1	Inorganic N fertilizers	N input from application of inorganic fertilizers to cropland and grassland	NA	-	NA	-	✓	-

IPCC code	Description	Description	CO_2		CH_4		N_2O	
			Estimated	Key Category	estimated	Key category	estimated	Key category
3.D.a.2	Organic N fertilizers	N input from organic N fertilizers to cropland and grassland	NA	-	NA	-	✓	-
3.D.a.2.a	Animal manure applied to soils	N input from manure applied to soils	NA	-	NA	-	✓	-
3.D.a.2.b	Sewage sludge applied to soils	N input from sewage sludge applied to soils	NA	-	NA	-	NE	-
3.D.a.2.c	Other organic fertilizers applied to soils	N input from application of other organic fertilizers	NA	-	NA	-	✓	-
3.D.a.3	Urine and dung deposited by grazing animals	N excretion on pasture, range and paddock	NA	-	NA	-	✓	-
3.D.a.4	Crop residues	N in crop residues returned to soils	NA	-	NA	-	✓	-
3.D.a.5	Mineralization/ immobilisation associated with loss/gain of soil organic matter	N in mineral soils that is mineralized in association with loss of soil C	NA	-	NA	-	NE	-
3.D.a.6	Cultivation of organic soils	Area of cultivated organic soils (i.e. histosols)	NA	-	NA	-	NE	
3.D.a.7	Other		NA	-	NA	-	NO	
3.D.b	**Indirect N_2O Emissions from managed soils**							LA 1990, 2017; TA
3.D.b.1	Atmospheric deposition	Volatilized N from agricultural inputs of N	NA	-	NA	-	✓	-
3.D.b.2	Nitrogen leaching and run-off	N from fertilizers and other agricultural inputs that is lost through leaching and run-off	NA	-	NA	-	✓	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential								
LA – Level Assessment (in year); TA – Trend Assessment								

In 2017, the source category 3.D was responsible for 97.5%% of agricultural nitrous oxide (N_2O) emissions and for 89.7% of the total nitrous oxide (N_2O) emissions estimated for Afghanistan.

It represented 27.3% of the total GHG emissions from the agriculture sector and 12.6% of the total GHG emissions in CO_2eq (excluding LULUCF).

In the period 1990 – 2017 the N_2O emissions increased by 81.7%. In the period 2005 – 2017 the N_2O emissions increased by 8.87% mainly due to increased

- amount of manure from increased number of livestock,
- amount of inorganic fertilizer,
- area for crop production which implicates increased
  - crop production,
  - crop residues.

An overview of the methane emissions resulting IPCC category 3.D Agricultural soils is provided in the following figures and tables.

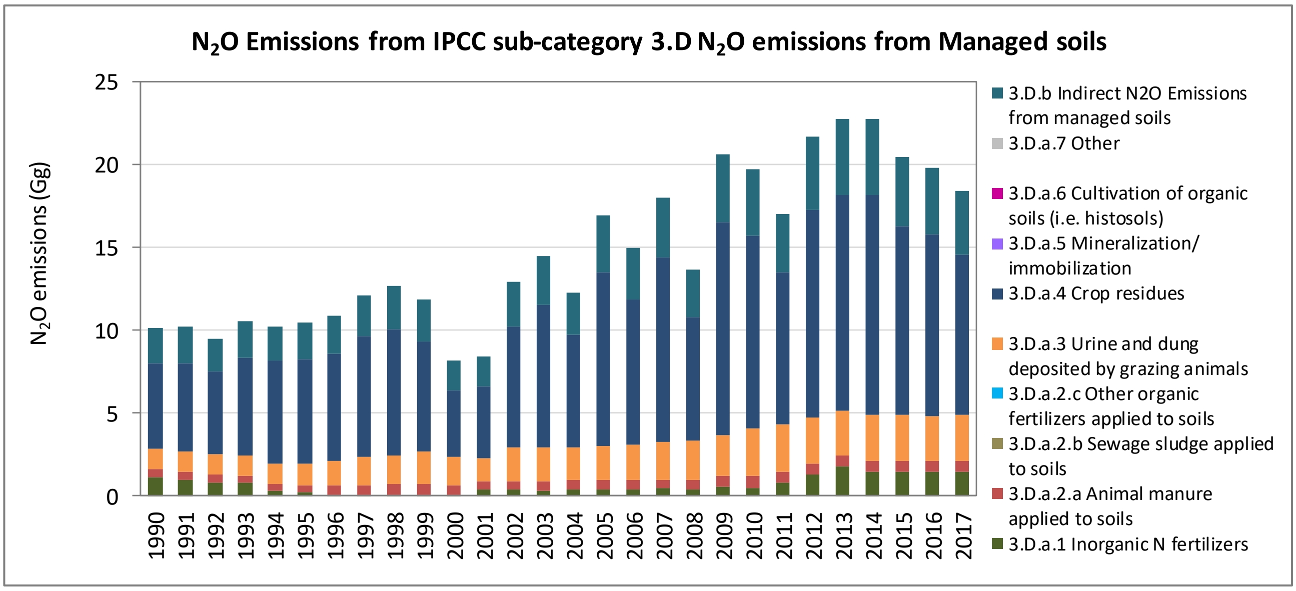


Figure 162 **N_2O Emissions from IPCC sub-category 3.D Agricultural soils**

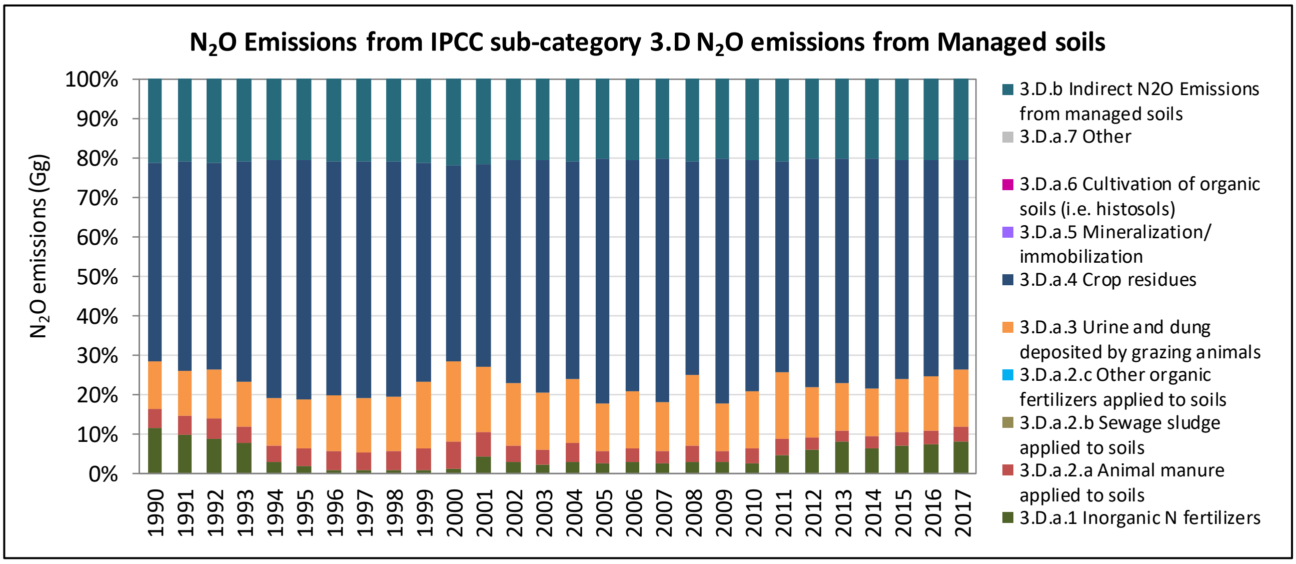


Figure 163 **Share of N_2O emissions of sub-categories in IPCC category 3.D Agricultural soils**

Table 257 N_2O Emissions from IPCC category 3.D Agricultural soils by sub-categories

N_2O emissions Agricultural soils	3.D	3.D.a	3.D.a.1	3.D.a.2	3.D.a.2.a	3.D.a.2.b	3.D.a.2.c	3.D.a.3	3.D.a.4	3.D.a.5	3.D.a.6	3.D.a.7	3.D.b	3.D.b.1	3.D.b.2
	Agricultural soils	**Direct N_2O emissions from managed soils**	Inorganic N fertilizers	Organic N fertilizers	Animal manure applied to soils	Sewage sludge applied to soils	Other organic fertilizers applied to soils	Urine and dung deposited by grazing animals	Crop residues	Minerali-sation/ immobili-sation	Cultivation of organic soils (i.e. histosols)	Other	**Indirect N_2O Emissions from managed soils**	Atmospheric deposition	Nitrogen leaching and run-off
		Gg	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**
1990	10.14	8.00	1.15	0.50	0.50	NE	NE	1.21	5.14	NE	NE	NO	2.14	0.36	1.78
1991	10.21	8.06	0.98	0.49	0.49	NE	NE	1.19	5.40	NE	NE	NO	2.14	0.35	1.79
1992	9.53	7.52	0.84	0.47	0.47	NE	NE	1.19	5.01	NE	NE	NO	2.01	0.34	1.67
1993	10.57	8.38	0.80	0.45	0.45	NE	NE	1.19	5.94	NE	NE	NO	2.19	0.33	1.86
1994	10.27	8.15	0.28	0.45	0.45	NE	NE	1.22	6.20	NE	NE	NO	2.13	0.32	1.81
1995	10.44	8.28	0.20	0.46	0.46	NE	NE	1.30	6.31	NE	NE	NO	2.16	0.33	1.83
1996	10.89	8.62	0.10	0.51	0.51	NE	NE	1.54	6.47	NE	NE	NO	2.27	0.38	1.90
1997	12.15	9.62	0.10	0.55	0.55	NE	NE	1.68	7.29	NE	NE	NO	2.53	0.41	2.12
1998	12.72	10.07	0.10	0.59	0.59	NE	NE	1.77	7.60	NE	NE	NO	2.65	0.44	2.22
1999	11.84	9.32	0.10	0.64	0.64	NE	NE	1.99	6.59	NE	NE	NO	2.52	0.48	2.04
2000	8.19	6.39	0.10	0.55	0.55	NE	NE	1.68	4.06	NE	NE	NO	1.80	0.41	1.39
2001	8.44	6.62	0.37	0.50	0.50	NE	NE	1.40	4.35	NE	NE	NO	1.82	0.36	1.46
2002	12.91	10.23	0.37	0.55	0.55	NE	NE	2.03	7.28	NE	NE	NO	2.67	0.46	2.22
2003	14.50	11.53	0.32	0.56	0.56	NE	NE	2.08	8.56	NE	NE	NO	2.97	0.46	2.51
2004	12.29	9.72	0.37	0.58	0.58	NE	NE	1.97	6.80	NE	NE	NO	2.57	0.46	2.11
2005	16.93	13.50	0.39	0.58	0.58	NE	NE	2.03	10.50	NE	NE	NO	3.43	0.47	2.96
2006	14.95	11.90	0.42	0.53	0.53	NE	NE	2.14	8.82	NE	NE	NO	3.05	0.47	2.58
2007	18.06	14.44	0.44	0.54	0.54	NE	NE	2.28	11.17	NE	NE	NO	3.62	0.48	3.14
2008	13.65	10.81	0.37	0.58	0.58	NE	NE	2.43	7.43	NE	NE	NO	2.84	0.52	2.32
2009	20.68	16.52	0.55	0.63	0.63	NE	NE	2.47	12.87	NE	NE	NO	4.16	0.55	3.61

N_2O emissions Agricultural soils	**3.D** **Agricultural soils**	**3.D.a** **Direct N_2O emissions from managed soils**	3.D.a.1 Inorganic N fertilizers	3.D.a.2 Organic N fertilizers	3.D.a.2.a Animal manure applied to soils	3.D.a.2.b Sewage sludge applied to soils	3.D.a.2.c Other organic fertilizers applied to soils	3.D.a.3 Urine and dung deposited by grazing animals	3.D.a.4 Crop residues	3.D.a.5 Minerali-sation/ immobili-sation	3.D.a.6 Cultivation of organic soils (i.e. histosols)	3.D.a.7 Other	**3.D.b** **Indirect N_2O Emissions from managed soils**	3.D.b.1 Atmospheric deposition	3.D.b.2 Nitrogen leaching and run-off
		Gg	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**
2010	19.76	15.73	0.52	0.69	0.69	NE	NE	2.90	11.61	NE	NE	NO	4.03	0.62	3.41
2011	17.03	13.48	0.78	0.72	0.72	NE	NE	2.86	9.12	NE	NE	NO	3.55	0.63	2.91
2012	21.70	17.29	1.29	0.69	0.69	NE	NE	2.72	12.59	NE	NE	NO	4.41	0.63	3.78
2013	22.77	18.16	1.80	0.68	0.68	NE	NE	2.71	12.98	NE	NE	NO	4.61	0.64	3.97
2014	22.79	18.18	1.46	0.69	0.69	NE	NE	2.77	13.26	NE	NE	NO	4.61	0.64	3.97
2015	20.47	16.28	1.46	0.69	0.69	NE	NE	2.73	11.40	NE	NE	NO	4.18	0.63	3.55
2016	19.84	15.77	1.46	0.69	0.69	NE	NE	2.72	10.91	NE	NE	NO	4.07	0.63	3.43
2017	18.41	14.61	1.46	0.69	0.69	NE	NE	2.72	9.74	NE	NE	NO	3.80	0.63	3.17
Trend															
1990 - 2017	81.7%	82.7%	26.4%	38.2%	38.2%	NA	NA	125.7%	89.5%	NA	NA	NA	77.9%	74.5%	78.5%
2005 - 2017	8.8%	8.2%	269.0%	20.0%	20.0%	NA	NA	33.9%	-7.2%	NA	NA	NA	11.0%	35.4%	7.2%
2016 - 2017	-7.2%	-7.4%	0.0%	0.5%	0.5%	NA	NA	0.0%	-10.7%	NA	NA	NA	-6.4%	0.1%	-7.6%

5.5.2 Direct N_2O emissions (IPCC category 3.D.a)

The following sources are included in IPCC category 3.D.a *Direct N_2O emissions from managed soils.*

3.D.a	**Direct N_2O emissions from managed soils**	
3.D.a.1	Inorganic N fertilizers	N input from application of inorganic fertilizers to cropland and grassland
3.D.a.2	Organic N fertilizers	N input from organic N fertilizers to cropland and grassland
3.D.a.2.a	Animal manure applied to soils	N input from manure applied to soils
3.D.a.2.b	Sewage sludge applied to soils	N input from sewage sludge applied to soils
3.D.a.2.c	Other organic fertilizers applied to soils	N input from application of other organic fertilizers
3.D.a.3	Urine and dung deposited by grazing animals	N excretion on pasture, range and paddock
3.D.a.4	Crop residues	N in crop residues returned to soils
3.D.a.5	Mineralization/ immobilization associated with loss/gain of soil organic matter	N in mineral soils that is mineralized in association with loss of soil C
3.D.a.6	Cultivation of organic soils (i.e. histosols)	Area of cultivated organic soils
3.D.a.7	Other	

In the period 1990 – 2017 the N_2O emissions increased by 82.7%. In the period 2005 – 2017 the N_2O emissions increased by 8.2% mainly due to increased

- amount of manure from increased number of livestock,
- amount of inorganic fertilizer,
- area for crop production which implicates increased
  - crop production,
  - crop residues.

5.5.2.1 Methodological issues

5.5.2.1.1 Choice of methods

For estimating the direct N_2O emissions from managed soils the 2006 IPCC Guidelines Tier 1 approach[166] has been applied.

TIER 1 approach – direct N_2O emissions from managed soils

The Tier 1 method (Equation 11.1) entails adding up the

- annual direct N_2O–N emissions produced from managed soils (kg N_2O–N)
- annual direct N_2O–N emissions from N inputs to managed soils (kg N_2O–N)
- annual direct N_2O–N emissions from managed organic soils (kg N_2O–N)
- annual direct N_2O–N emissions from urine and dung inputs to grazed soils (kg N_2O–N)

and converting the N_2O–N emissions to N_2O emissions for reporting purposes.

[166] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap 11.2.1.1 Choice of method. Page 11.6.

Equation: Conversion N_2O emissions from of N_2O–N emissions (2006 IPCC GL, Vol. 4, Chap. 11)

$$N_2O\ emissions_{direct} = N_2O - N \times \frac{44}{28}$$

Equation 11.1: Direct N_2O emissions from managed soils

$$N_2O\ emissions_{direct} - N = N_2O - N_{N\ inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

Where:

N_2O emissions $_{direct}$ = direct N_2O emissions from managed soils (kg N_2O)

N_2O_{Direct} –N = annual direct N_2O–N emissions produced from managed soils (kg N_2O–N)

$N_2O–N_{N\ inputs}$ = annual direct N_2O–N emissions from N inputs to managed soils (kg N_2O–N)

$N_2O–N_{OS}$ = annual direct N_2O–N emissions from managed organic soils (kg N_2O–N)

$N_2O–N_{PRP}$ = annual direct N_2O–N emissions from urine and dung inputs to grazed soils (kg N_2O–N) with PRP = pasture, range and paddock

Equation 11.1: Direct N_2O emissions from managed soils (2006 IPCC GL, Vol. 4, Chap. 11) [167]

$$N_2O\ emissions_{direct} - N = N_2O - N_{N\ inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

Where

Annual direct N_2O–N emissions from N inputs to managed soils **(11.1.a)**

$$N_2O - N_{N\ inputs} = \begin{bmatrix} [(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \times EF_1] + \\ [(F_{SN} + F_{ON} + F_{CR} + F_{SOM})_{FR} \times EF_{1FR}] \end{bmatrix}$$

Annual direct N_2O–N emissions from managed organic soils **(11.1.b)**

$$N_2O - N_{OS} = \begin{bmatrix} (F_{OS,CG,Temp} \times EF_{2CG,Temp}) + (F_{OS,CG,Trop} \times EF_{2CG,Trop}) + \\ (F_{OS,F,Temp,NR} \times EF_{2F,Temp,NR}) + (F_{OS,F,Temp,NP} \times EF_{2F,Temp,NP}) \\ +(F_{OS,F,Trop} \times EF_{2F,Trop}) \end{bmatrix}$$

Annual direct N_2O–N emissions from urine and dung inputs to grazed soils **(11.1.c)**

$$N_2O - N_{PRP} = [(F_{PRP,CPP} \times EF_{3PRP,CPP}) + (F_{PRP,SO} \times EF_{3PRP,SO})]$$

Where:

N_2O emissions $_{direct}$ = direct N_2O emissions from managed soils (kg N_2O)

N_2O_{Direct} –N = annual direct N_2O–N emissions produced from managed soils (kg N_2O–N)

$N_2O–N_{N\ inputs}$ = annual direct N_2O–N emissions from N inputs to managed soils (kg N_2O–N)

$N_2O–N_{OS}$ = annual direct N_2O–N emissions from managed organic soils (kg N_2O–N)

$N_2O–N_{PRP}$ = annual direct N_2O–N emissions from urine and dung inputs to grazed soils (kg N_2O–N) with PRP = pasture, range and paddock

F_{SN} = annual amount of synthetic fertiliser N applied to soils (kg N)

F_{ON} = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils

F_{CR} = annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N yr^{-1}

[167] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap 11.2.1.1 Choice of method. Equation 11.1 direct N_2O emissions from managed soils (TIER 1). Page 11.7.

F_{SOM}	= annual amount of N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N yr^{-1}
F_{OS}	= annual area of managed/drained organic soils, ha *(Note: the subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively)*
F_{PRP}	= annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1} (Note: the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively)
EF_1	= emission factor for N_2O emissions from N inputs, kg N_2O–N (kg N input)$^{-1}$
EF_{1FR}	= emission factor for N_2O emissions from N inputs to flooded rice, kg N_2O–N (kg N input)$^{-1}$
EF_2	= emission factor for N_2O emissions from drained/managed organic soils, kg N_2O–N ha-1 yr^{-1} *(Note: the subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively)*
$EF_{3\ PRP}$	= emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, kg N_2O–N (kg N input)$^{-1}$; *(Note: the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively)*

For better understanding the processes in soil and crust the following figures provide simplified illustration of nitrogen (N) transactions

• between the atmosphere and liquid manure with emphasis on critical processes involved in the emission of gases	Figure 164
• the atmosphere and the soil with emphasis on agronomic aspects related to plant fertilization and the reactions involved in the formation and emission of nitrous oxide (direct and indirect).	Figure 165

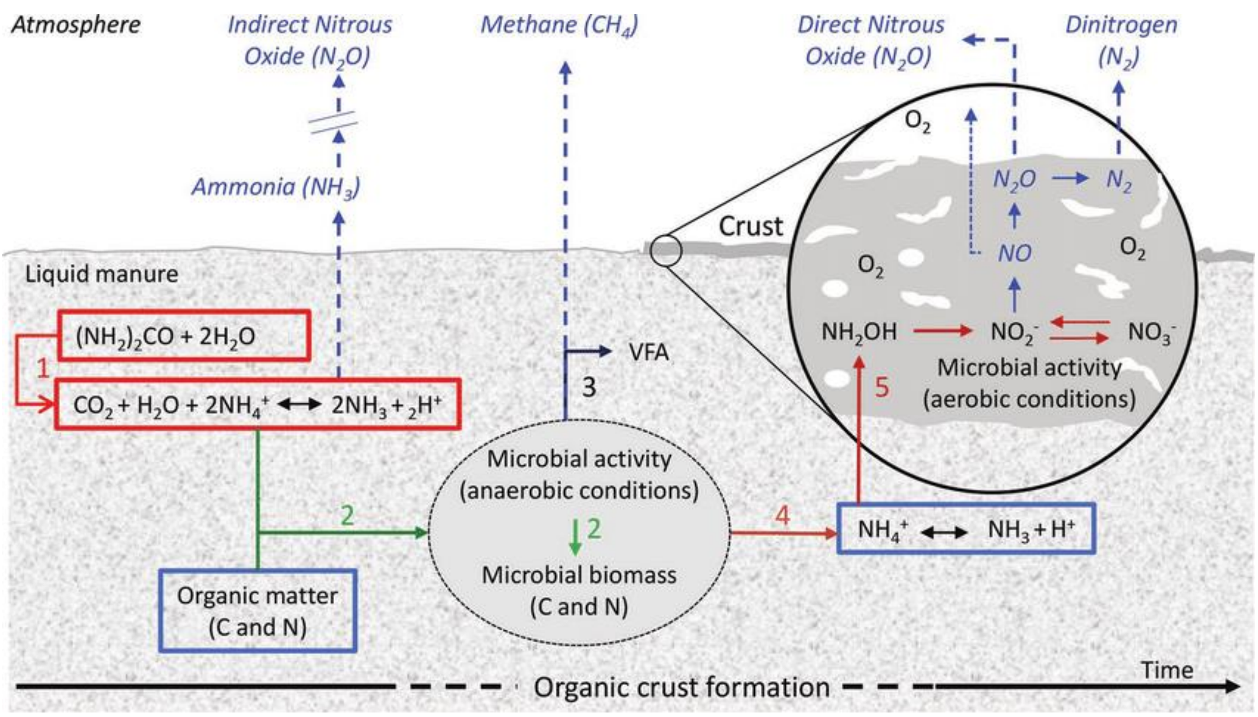


Figure 164 Simplified illustration of N transactions between the atmosphere and liquid manure with emphasis on critical processes involved in the emission of gases

Simplified illustration of N transactions between the atmosphere and liquid manure (data from Aguerre et al., 2012), with emphasis on critical processes involved in the emission of gases: (1) hydrolysis of urinary urea-N (giving rise to ammonia, which after emission and deposition on soils contributes to indirect nitrous oxide emission), microbial fermentation of OM under anaerobic conditions (giving rise to methane) associated with (2) microbial growth, (3) acidification of the medium through the formation of VFA, and (4) ammonia formation from the degradation of N-containing organic compounds. In addition, when an organic crust formed (5), the nitrification of ammonium under aerobic conditions was responsible for nitrous oxide and presumably dinitrogen emissions.

Nitrogen-containing structures are as follows:

$(NH_2)_2CO$ = urea; NH_4^+ = ammonium; NH_3 = ammonia; NH_2OH = hydroxylamine; NO_2^- = nitrite; NO_3^- = nitrate; NO = nitric oxide (emitted gas); N_2O = nitrous oxide; N_2 = dinitrogen.

Source: WATTIAUX, M. A.; PAS, UDDIN, M. E. ; LETELIER, P., JACKSON, R. D. & LARSON, R. A. (2019): Emission and mitigation of greenhouse gases from dairy farms: The cow, the manure, and the field. In: Applied Animal Science 35:238–254. Sustainability and Integrated Systems. https://doi.org/10.15232/aas.2018-01803

Available on 29.04.2019 at: https://www.researchgate.net/publication/331916870_Invited_Review_Emission_and_mitigation_of_greenhouse_gases_from_dairy_farms_The_cow_the_manure_and_the_field

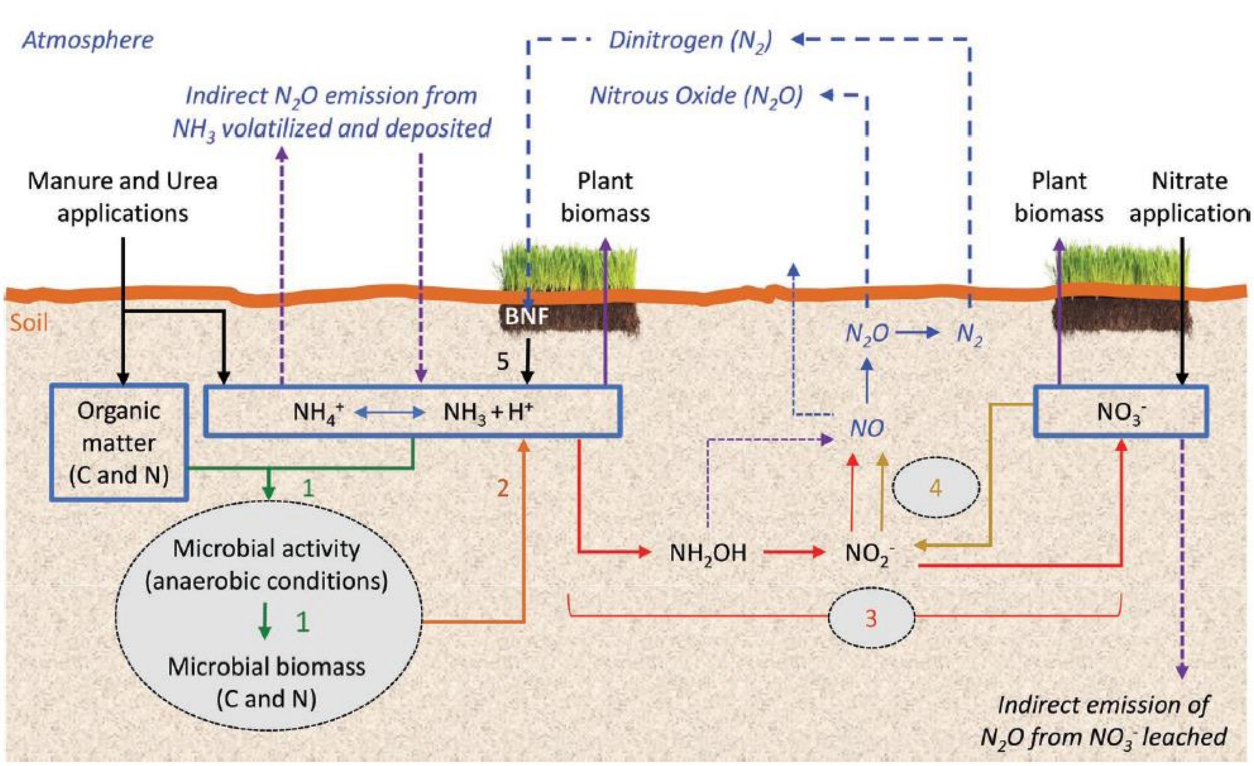


Figure 165 Simplified illustration of N transactions between the atmosphere and the soil with emphasis on agronomic aspects related to plant fertilization and the reactions involved in the formation and emission of nitrous oxide (direct and indirect)

Simplified illustration of N transactions between the atmosphere and the soil with emphasis on agronomic aspects related to plant fertilization and the reactions involved in the formation and emission of nitrous oxide (direct and indirect). Different types of arrows are used to identify the main transformations associated with (1) immobilization, (2) mineralization, (3) nitrification, (4) denitrification, and (5) biological nitrogen fixation (BNF) by legumes.

Nitrogen-containing structures are as follows:

N_2 = dinitrogen; NH_3 = ammonia; $NH4^+$ = ammonium; NH_2OH = hydroxylamine;

NO = nitric oxide (emitted gas); NO_2^- = nitrite; NO_3^- = nitrate; N_2O = nitrous oxide

Source: WATTIAUX, M. A.; PAS, UDDIN, M. E. ; LETELIER, P., JACKSON, R. D. & LARSON, R. A. (2019): Emission and mitigation of greenhouse gases from dairy farms: The cow, the manure, and the field. In: Applied Animal Science 35:238–254. Sustainability and Integrated Systems. https://doi.org/10.15232/aas.2018-01803

Available on 29.04.2019 at: https://www.researchgate.net/publication/331916870_Invited_Review_Emission_and_mitigation_of_greenhouse_gases_from_dairy_farms_The_cow_the_manure_and_the_field

5.5.2.1.2 Choice of activity data (AD) and emission factor (EF)

In the following subchapters/sections the activity data (AD) and emission factors (EF) as well as the emission calculations and results are presented separately for each N input from

1) Applied synthetic fertilizer (F_{SN})	$$N_2O-N_{N\ inputs}=\begin{bmatrix}[(F_{SN})\times EF_1]+\\ [(F_{SN})_{FR}\times EF_{1FR}]\end{bmatrix}$$ *See above equation 11.1.a*[167]
2) Applied organic N fertilizer (F_{ON})	$$N_2O-N_{N\ inputs}=\begin{bmatrix}[(F_{ON})\times EF_1]+\\ [(F_{ON})_{FR}\times EF_{1FR}]\end{bmatrix}$$ *See above equation 11.1.a*[167]
3) annual amount of N in crop residues, including N-fixing crops, and from forage/pasture renewal, returned to soils (F_{CR})	$$N_2O-N_{N\ inputs}=\begin{bmatrix}[(F_{CR})\times EF_1]+\\ [(F_{CR})_{FR}\times EF_{1FR}]\end{bmatrix}$$ *See above equation 11.1.a*[167]
4) Mineralised N resulting from loss of soil organic C stocks in mineral soils through land-use change or management practices (F_{SOM})	$$N_2O-N_{N\ inputs}=\begin{bmatrix}[(F_{SOM})\times EF_1]+\\ [(F_{SOM})_{FR}\times EF_{1FR}]\end{bmatrix}$$ *See above equation 11.1.a*[167]

5) Area of drained/managed organic soils (F_{OS})	*See above equation 11.1.b*[167]
6) Urine and dung from grazing animals (F_{PRP})	*See above equation 11.1.c*[167]

5.5.2.1.2.1 AD and calculation for *N Input from Applied synthetic fertilizer (F_{SN})*

Activity data, parameter and emission calculation for *N Input from Applied synthetic fertilizer (F_{SN})*

The data of annual amount of applied synthetic fertilizer (F_{SN}) consumption is taken from international source: FAO agricultural data base on synthetic fertilizer consumption[130].

The information on fertilizer consumption / distribution of the Afghanistan Statistical yearbook[128] was used only for crosscheck.

As the split of fertilizer used in for crops and for flooded rice fields was not well known it was assumed that the total amount of synthetic fertilizer consumed annually was used for crop production. This is also a conservative assumption in order to avoid underestimation as the EF for flooded rice fields is 10 times lover than the EF for crops. See here also the planned improvement in chapter 5.5.7.

Default emission factors (EF_1) and (EF_{1FR}) were taken from Table 11.1 of 2006 IPCC Guidelines, Vol. 4, Chap. 11[168] and are presented in the following table.

[168] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap 11.2.1.2 Choice of emission factor. Table 11.1. Page 11.11.

Table 258 Default emission factors to estimate direct N_2O emissions from managed soils

Emission factor		N_2O (kg N_2O–N (kg N)$^{-1}$) EF	type	Source: 2006 IPCC Guidelines Vol. 4, Chap. 11 (11.2.1.2)
EF_1 for N additions from mineral fertilizers, organic amendments and crop residues, and N mineralized from mineral soil as a result of loss of soil carbon	EF_1	0.01	D	**Table 11.1** Default emission factors to estimate direct N_2O emissions from managed soils (page 11.11)
EF_{1FR} for flooded rice fields [kg N_2O–N (kg N)-1]	EF_{1FR}	0.003	D	

Note:

D	Default	CS	Country specific	PS	Plant specific	IEF	Implied emission factor

With the Equation 11.1.a (see also in section 5.5.2.1.1 Choice of methods) and the equation for conversion N_2O-N tot N_2O the N_2O emissions from N inputs to managed soils

Annual direct N_2O–N emissions from N inputs to managed soils (2006 IPCC GL, Vol. 4, Chap. 11) [167]

$$N_2O - N_{N\ inputs} = [[(F_{SN}) \times EF_1] + [(F_{SN})_{FR} \times EF_{1FR}]] \qquad \textbf{(11.1.a)}$$

$$N_2O\ emissions_{direct} = N_2O - N \times \frac{44}{28}$$

Table 259 Nitrous oxide emissions from N Input from Synthetic Fertilizers Application

Parameter	Consumption of synthetic fertilizers	N Input from synthetic fertilizers application to: crops	flooded rice	Emission Factor - N_2O-N for: crops	flooded rice	N_2O-N emissions	N_2O emissions	Method	EF used
Abbreviation	N_{FERT}	F_{SN}	$(F_{SN})_{FR}$	EF_1 - N_2O-N	EF_{1FR} - N_2O-N	N_2O-N	N_2O		
Unit	t N	kg N		kg N_2O-N/kg N		Gg	Gg		
1990	73,269	73,268,750	NO	0.01	0.003	0.73	1.15	T1	D
1991	62,183	62,182,870	NO	0.01	0.003	0.62	0.98	T1	D
1992	53,518	53,518,043	NO	0.01	0.003	0.54	0.84	T1	D
1993	50,970	50,969,565	NO	0.01	0.003	0.51	0.80	T1	D
1994	17,839	17,839,348	NO	0.01	0.003	0.18	0.28	T1	D
1995	12,742	12,742,391	NO	0.01	0.003	0.13	0.20	T1	D
1996	6,371	6,371,196	NO	0.01	0.003	0.06	0.10	T1	D
1997	6,371	6,371,196	NO	0.01	0.003	0.06	0.10	T1	D
1998	6,371	6,371,196	NO	0.01	0.003	0.06	0.10	T1	D
1999	6,371	6,371,196	NO	0.01	0.003	0.06	0.10	T1	D
2000	6,371	6,371,196	NO	0.01	0.003	0.06	0.10	T1	D
2001	23,446	23,446,000	NO	0.01	0.003	0.23	0.37	T1	D
2002	23,446	23,446,000	NO	0.01	0.003	0.23	0.37	T1	D
2003	20,320	20,320,000	NO	0.01	0.003	0.20	0.32	T1	D
2004	23,383	23,383,000	NO	0.01	0.003	0.23	0.37	T1	D
2005	25,096	25,096,000	NO	0.01	0.003	0.25	0.39	T1	D

Parameter	Consumption of synthetic fertilizers	N Input from synthetic fertilizers application to		Emission Factor - N_2O-N for		N_2O-N emissions	N_2O emissions	Method	EF used
		crops	flooded rice	crops	flooded rice				
Abbreviation	N_{FERT}	F_{SN}	$(F_{SN})_{FR}$	EF_1 - N_2O-N	EF_{1FR} - N_2O-N	N_2O-N	N_2O		
Unit	t N	kg N		kg N_2O-N/kg N		Gg	Gg		
2006	26,651	26,650,500	NO	0.01	0.003	0.27	0.42	T1	D
2007	28,205	28,205,000	NO	0.01	0.003	0.28	0.44	T1	D
2008	23,289	23,289,000	NO	0.01	0.003	0.23	0.37	T1	D
2009	35,236	35,236,000	NO	0.01	0.003	0.35	0.55	T1	D
2010	33,159	33,159,000	NO	0.01	0.003	0.33	0.52	T1	D
2011	49,936	49,936,000	NO	0.01	0.003	0.50	0.78	T1	D
2012	82,116	82,116,190	NO	0.01	0.003	0.82	1.29	T1	D
2013	114,296	114,296,380	NO	0.01	0.003	1.14	1.80	T1	D
2014	92,616	92,616,000	NO	0.01	0.003	0.93	1.46	T1	D
2015	92,616	92,616,000	NO	0.01	0.003	0.93	1.46	T1	D
2016	92,616	92,616,000	NO	0.01	0.003	0.93	1.46	T1	D
2017	92,616	92,616,000	NO	0.01	0.003	0.93	1.46	T1	D

5.5.2.1.2.2 AD and calculation for N Input from *Applied organic N fertilizer (F_{ON})*

Activity data, parameter and emission calculation for N Input from *Applied organic N fertilizer (F_{ON})*

The data of annual amount of applied organic fertilizer (F_{ON}) is calculated according the following equation taken from 2006 IPCC Guidelines, Vol. 4, Chap. 11[169] .

Equation 11.3: N from organic N additions applied to soils (TIER 1) (2006 IPCC GL, Vol. 4, Chap. 11) [169]

$$F_{ON} = F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$$

Where:

F_{ON} = total annual amount of organic N fertiliser applied to soils other than by grazing animals (kg N yr^{-1})

F_{AM} = annual amount of animal manure N applied to soils (kg N yr^{-1})

F_{SEW} = annual amount of total sewage N (coordinate with Waste Sector to ensure that sewage N is not double-counted) that is applied to soils (kg N yr^{-1})

F_{COMP} = annual amount of total compost N applied to soils (ensure that manure N in compost is not double-counted), kg N yr^{-1}

F_{OOA} = annual amount of other organic amendments used as fertiliser (e.g., rendering waste, guano, brewery waste, etc.) (kg N yr^{-1})

[169] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap 11.2.1.3 Choice of activity data. Page 11.13.

F_{AM} - annual amount of animal manure N applied to soils

The term F_{AM} is determined by adjusting the amount of manure N available (N_{MMS_Avb}) for the amount of

- managed manure used for feed ($Frac_{FEED}$),
- burned for fuel ($Frac_{FUEL}$), or
- used for construction ($F_{racCNST}$)

Equation 11.4: N from animal manure applied to soils (TIER 1)
(2006 IPCC GL, Vol. 4, Chap. 11)[170]
$\boldsymbol{F_{AM} = N_{MMS\ Avb} \times [1 - (Frac_{Feed} + Frac_{Fuel} + Frac_{CNST})]}$

Where:

F_{AM} = annual amount of animal manure N applied to soils (kg N yr^{-1})

N_{MMS_Avb} = amount of managed manure N available for soil application, feed, fuel or construction, (kg N yr^{-1}) *(Equation 10.34 in Chapter 10 of Vol. 4 of 2006 IPCC GL*[171]*)*

$Frac_{FEED}$ = fraction of managed manure used for feed

$Frac_{FUEL}$ = fraction of managed manure used for fuel

$Frac_{CNST}$ = fraction of managed manure used for construction

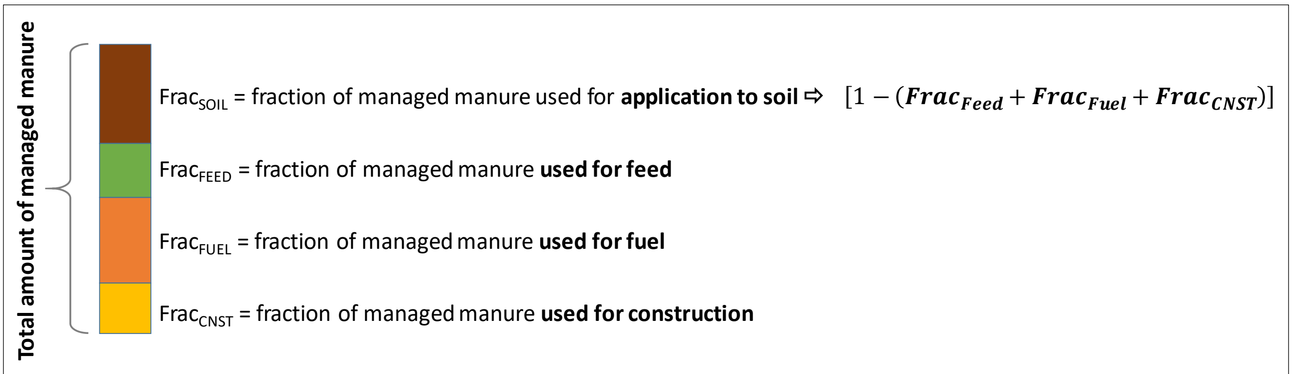


Figure 166 Fraction of of managed animal manure used for different purposes.

Data for $Frac_{FUEL}$, $Frac_{FEED}$, $Frac_{CNST}$ was not available therefore N_{MMS_Avb} was used as F_{AM} without adjusting for $Frac_{FUEL}$, $Frac_{FEED}$, $Frac_{CNST}$, which is also proposed by 2006 IPCC GL[130].

Finally, the managed manure nitrogen available for

- (a) application to managed soils,
- (b) for use in feed, fuel, or construction purposes (assumed be 0)

is estimated according to Equation 10.34 of Vol. 4 of 2006 IPCC GL[171].

[170] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application. Sub-chap. 11.2.1.3. Equation 11.4. Page 11.13.

[171] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10: Emissions from Livestock and Manure Management, sub-chap. 10.5.4 Coordination with reporting for N_2O emissions from managed soils. Page 10.64.

Equation 10.34: Managed manure N available for application to managed soils, feed, fuel or construction uses (2006 IPCC GL, Vol. 4, Chap. 10.5.4)

$$N_{NMS\_Avb} = \sum_{S}\left\{\sum_{(T)}\left[\left[\left(N_{(T)} \times Nex_{(T)} \times MS_{(T,S)}\right) \times \left(1 - \frac{Frac_{LossMS}}{100}\right)\right] + \left[N_{(T)} \times MS_{(T,S)} \times N_{beddingMS}\right]\right]\right\}$$

Where:

$NMMS_{\_Avb}$ = amount of managed manure nitrogen available for application to managed soils or for feed, fuel, or construction purposes (kg N yr^{-1})

$N_{(T)}$ = number of head of livestock species/category T

$Nex_{(T)}$ = annual average N excretion per animal of species/category T (kg N $animal^{-1}$ $^{yr-1}$)

$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S, dimensionless

$Frac_{LossMS}$ = amount of managed manure nitrogen for livestock category T that is lost in the manure management system S (%)

$N_{beddingMS}$ = amount of nitrogen from bedding (to be applied for solid storage and deep bedding MMS if known organic bedding usage) (kg N animal-1 $^{yr-1}$)

S = manure management system

T = species/category of livestock

Data used for estimation the amount of managed manure nitrogen available for application to managed soils or for feed, fuel, or construction purposes were already used in other categories of IPCC Sector *Agriculture* and presented front sections.

$N_{(T)}$ - Number of head of livestock species/category T

The activity data are the same as used in category 3.A Enteric Fermentation and 3.B Manure Management and are presented in Table 230, Table 231, Table 232.

$Nex_{(T)}$ - Annual average N excretion per animal of species/category T

The annual average N excretion per animal of species/category T ($Nex_{(T)}$) is calculated with Equation 10.30 of 2006 IPCC GL[172], presented in Table 245 and exemplarily calculated in Table 246 (direct N_2O emissions) in Chapter 5.3.2.

$MS_{(T,S)}$ - fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S

The fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S is defined in Table 239 and is presented in Table 240.

$Frac_{LossMS}$ - amount of managed manure nitrogen for livestock category T that is lost in the manure management systems

Default values for total nitrogen loss from manure management was taken from Table 10.23 of 2006 IPCC GL[173] and are presented in the following table. These default values include losses that occur from the point of excretion, including animal housing losses, manure storage losses, and losses from leaching and runoff at the manure storage system where applicable.

[172] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10: Emissions from Livestock and Manure Management, sub-chapter 10.5.2 Choice of emission factors, p. 10.57.

[173] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10: Emissions from Livestock and Manure Management, sub-chapter 10.5.5 Uncertainty assessment, Table 10.23 Default values for total nitrogen loss from manure management. P. 10.67.

Table 260 Default values for nitrogen loss due to volatilization of NH_3 and NO_x from manure management

Animal type	Manure management system (MMS)	Total N loss from MMS ($Frac_{LossMS}$)
Dairy Cow	Liquid/Slurry	40%
	Solid storage	40%
	Daily spread	22%
Poultry	Poultry without litter	55%
	Poultry with litter	50%
Other Cattle	Solid storage	50%
	Deep bedding	40%
Other (includes sheep, horses, and fur-bearing animals)	Deep bedding	35%
	Solid storage	15%

Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10: Emissions from Livestock and Manure Management, sub-chapter 10.5.5 Uncertainty assessment, Table 10.22: Default values for nitrogen loss due to volatilization of NH_3 and NO_x from manure management, p. 10.67.

$N_{beddingMS}$ - amount of nitrogen from bedding

Bedding materials vary greatly and are depending on the characteristics of bedding material used in their livestock industries. Due to lack of data in this inventory cycle, it was assumed that this manure management did not exist in the country. See also planned improvements.

F_{SEW} - Annual amount of total sewage N that is applied to soils

The annual amount of total sewage sludge applied to soils depends on the sewage practices which is quite different between rural and urban regions. In Afghanistan the (sewage) sludge from urban areas was mainly dumped to rivers. In rural areas some amount of sludge was applied to agriculture. Information about amount sewage sludge and related N content was not available. Therefore, this source of nitrogen was not estimated. (See also planned improvements in chapter 5.5.7.)

N_2O emissions from wastewater treatment is entirely estimated in Chapter 7.5.

Double counting is therefore excluded.

F_{COMP} - Annual amount of total compost N applied to soil

The annual amount of compost applied to soils depends on the composting activities within the country. In Afghanistan composting was practiced in urban and rural areas (see Figure 198). Also, it was assumed that about 3 % of the municipal solid waste (MSW) – here the organic fraction-, is used in the agriculture sector, mainly as feed for animals but also for composting. However, information about amount of compost applied to soil and related N content was not available. Therefore, this source of nitrogen was not estimated. (See also planned improvement)

N_2O Emissions from biological treatment is entirely estimated in Chapter 7.3.

Double counting is therefore excluded.

F_{OOA} - annual amount of other organic amendments used as fertiliser

No information about amount of other organic amendments (e.g., rendering waste, guano, brewery waste, etc.) used as fertilizer was not available. Therefore, this source of nitrogen was not estimated. (See also planned improvement).

Table 261 Exemplary calculation of direct N_2O emissions from applied organic N fertilizer (F_{ON}) for 2017 applying TIER 1 approach

Parameter	Parameter description	Unit	Formula	Parameter Source	2017
Nex	Nitrogen Excretion - Solid Storage - Dairy Cattle	kg N/year	NTxNexTxMS	See also Table 246	12,660,843
Nex	Nitrogen Excretion - Solid Storage - Non-Dairy Cattle	kg N/year	NTxNexTxMS	See also Table 246	5,858,464
Nex	Nitrogen excretion per AWMS - Solid storage - Sheep	kg N/year	NTxNexTxMS		19,685,557
Nex	Nitrogen excretion per AWMS - Solid storage - Goats	kg N/year	NTxNexTxMS		3,646,074
Nex	Nitrogen excretion per AWMS - Solid storage - Horses	kg N/year	NTxNexTxMS		2,422,822
Nex	Nitrogen excretion per AWMS - Solid storage – Mules and Asses	kg N/year	NTxNexTxMS		12,203,544
Nex	Nitrogen excretion per AWMS - Solid storage - Poultry	kg N/year	NTxNexTxMS		2,682,025
$Frac_{LossMS}$	Dairy Cattle - Solid Storage	%		Table 10.22, 2006 IPCC GL, Chap. 10.5.4, Vol. 4, page 10.65	40%
$Frac_{LossMS}$	Other Cattle - Solid Storage	%			50%
$Frac_{LossMS}$	Poultry	%			55%
$Frac_{LossMS}$	Other (Horse, Camel, Mules and Asses)	%			15%
N_{MMS_Avb}	N Input from manure applied to soils or for feed, fuel, or construction purposes - Dairy Cattle - Solid storage	kg N/year	[∑j[(NexTjx(1-FracLossMS/100)]	Equation 10.34, 2006 IPCC GL, Chap. 10.5.4, Vol. 4, page 10.65	7,596,506
N_{MMS_Avb}	N Input from manure applied to soils or for feed, fuel, or construction purposes - Non-Dairy Cattle - solid storage	kg N/year	[∑j[(NexTjx(1-FracLossMS/100)]		2,929,232
N_{MMS_Avb}	N Input from manure applied to soils or for feed, fuel, or construction purposes - Sheep	kg N/year	[∑j[(NexTjx(1-FracLossMS/100)]		16,732,723
N_{MMS_Avb}	N Input from manure applied to soils or for feed, fuel, or construction purposes - Goats	kg N/year	[∑j[(NexTjx(1-FracLossMS/100)]		3,099,163
N_{MMS_Avb}	N Input from manure applied to soils or for feed, fuel, or construction purposes - Horses	kg N/year	[∑j[(NexTjx(1-FracLossMS/100)]		2,059,399
N_{MMS_Avb}	N Input from manure applied to soils or for feed, fuel, or construction purposes - Mules & Asses	kg N/year	[∑j[(NexTjx(1-FracLossMS/100)]		10,373,012
N_{MMS_Avb}	N Input from manure applied to soils or for feed, fuel, or construction purposes - Poultry	kg N/year	[∑j[(NexTjx(1-FracLossMS/100)]		1,206,911

Parameter	Parameter description	Unit	Formula	Parameter Source	2017
N_{MMS_Avb}	N Input from manure applied to soils or for feed, fuel, or construction purposes - Total	kg N/year	[∑j[(NexTjx(1-FracLossMS/100)]		43,996,947
F_{AM}	N Input from Manure Applied to Soils	kg N/year	FAM = $N_{MMS\ Abv}$	Equation 11.4, 2006 IPCC GL, Vol. 4, Chap. 11.2.1.3. Page 11.12	43,996,947
EF_1 - N_2O-N	Emission Factor - N_2O-N	kg N_2O-N/kg N		Table 11.1, 2006 IPCC GL, Vol. 4, Chap. 11.2.1.2. page 11.11 See also Table 258	0.01
N_2O-N	N_2O-N emissions	Gg	(EF_1xFAM)/10^6	Equation 11.1, 2006 IPCC GL, Vol. 4, Chap. 11.2.1.3. Page 11.7	0.44
N_2O	**N_2O emissions**	**Gg**	N_2O-Nx(44/28)		**0.69**
N_2O	Method	-			T1
N_2O	EF used	-			D

5.5.2.1.2.3 AD and calculation for *N Input from annual amount of N in crop residues (F_{CR})*

Activity data, parameter and emission calculation for N Input from annual amount of *N in crop residues, including N-fixing crops, and from forage/pasture renewal, returned to soils (F_{CR})*

The term F_{CR} refers to the amount of N in crop residues (above-ground and below-ground), including N-fixing crops, returned to soils annually. It also includes the N from N-fixing and non-N-fixing forages mineralised during forage or pasture renewal. It is estimated from crop yield statistics and default factors for above-/ belowground residue: yield ratios and residue N contents.

Equation 11.6: N from crop residues and forage/pasture renewal (TIER 1)
2006 IPCC GL, Vol. 4, Chap. 11.2.1.3)

$$F_{CR} = \sum_{T}\{Crop_{(T)} \times Frac_{Renew(T)} \times [(Area_{(T)} - Area_{\,burnt\,(T)} \times C_F) \times R_{AG(T)} \times N_{AG(T)} \times (1 - Frac_{Remove(T)}) + Area_{(T)} - R_{BG(T)} \times N_{BG(T)}]\}$$

As no country specific data were available the recommended alternative approach was applied for estimating the amount of N in crop residues (above-ground and below-ground), including N-fixing crops, returned to soils annually.

Equation 11.7A: N from crop residues and forage/pasture renewal (TIER 1)

Alternative approach to estimate F_{CR} (using Table 11.2)
2006 IPCC GL, Vol. 4, Chap. 11.2.1.3

$$F_{CR} = \sum_{T}\{Frac_{Renew(T)} \times [(Area_{(T)} - Area_{\,burnt\,(T)} \times C_F) \times AG_{DM(T)} \times 1000 \times N_{AG(T)} \times (1 - Frac_{Remove(T)}) + Area_{(T)} \times (AG_{DM(T)} \times 1000 + Crop_{(T)}) \times R_{BG-BIO(T)} \times N_{BG(T)}]\}$$

Where:

F_{CR} = annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually (kg N yr^{-1})

$Crop_{(T)}$ = harvested annual dry matter yield for crop T (kg d.m. ha-1)

$Area_{(T)}$ = total annual area harvested of crop T (ha $^{yr-1}$)

Area burnt $_{(T)}$ = annual area of crop T burnt (ha $^{yr-1}$)

C_f = combustion factor (dimensionless)

referred to 2006 IPCC GL, Vol. 4, Chapter 2, Table 2.6

$AG_{DM(T)}$ = above-ground residue dry matter (Mg/ha)

see equation below

$N_{AG(T)}$ = N content of above-ground residues for crop T (kg N (kg d.m.) $^{-1}$;

see Table 271 which is based on Table 11.2 of 2006 IPCC GL, Vol. 4, Chapter 11

$Frac_{Remove(T)}$ = fraction of above-ground residues of crop T removed annually for purposes such as feed, bedding and construction, kg N (kg crop-N)$^{-1}$.

No data for $Frac_{Remove}$ were available, thus no removal is assumed.

$R_{BG-BIO(T)}$ = Ratio of belowground residues to above-ground biomass (kg d.m. (kg d.m.)$^{-1}$) by the ratio of total above-ground biomass to crop yield.

see Table 271 which is based on Table 11.2 of 2006 IPCC GL, Vol. 4, Chapter 11

$N_{BG(T)}$ = N content of below-ground residues for crop T (kg N (kg d.m.)$^{-1}$)

see Table 271 which is based on Table 11.2 of 2006 IPCC GL, Vol. 4, Chapter 11

T = crop or forage type: wheat, potatoes, beans, etc.

The term $AG_{DM(T)}$ refers to the above-ground residue dry matter and is calculated according to the following equation.

Equation for calculation of the above-ground residue dry matter ($AG_{DM(T)}$)
2006 IPCC GL, Vol. 4, Chap. 11.2.1.3, Table 11.2)

$$AG_{DM(T)} = \frac{Crop_{(T)}}{1000} \times slope_{(T)} \times + intercept_{(T)}$$

The yield statistics for all crops are reported as fresh weight, a correction factor needs to be applied to estimate dry matter yields ($Crop_{(T)}$) following the Equation 11.7 of 2006 IPCC GL, Vol. 4, Chap. 11. The default values for dry matter content given in following tables and were taken from Table 11.2 of 2006 IPCC GL, Vol. 4, Chap. 11. may be used.

Equation 11.7: Dry-weight correction of reported crop yields
(2006 IPCC GL, Vol. 4, Chap. 11.2.1.3)

$$Crop_{(T)} = Yield\ Fresh_{(T)} \times DRY$$

Where:

$Crop_{(T)}$ = harvested dry matter yield for crop T (kg d.m. ha^{-1})

$Yield\_Fresh_{(T)}$ = harvested fresh yield for crop T (kg fresh weight ha^{-1})

DRY = dry matter fraction of harvested crop T (kg d.m. (kg fresh weight)-^{1})

The data on area of cultivated crops and amount of harvested fresh yield of crops were taken for the years 1996-1997, 2000-2017 from Afghanistan Statistical Yearbooks (different years) published by NSIA and were completed with data from FAO STAT[174]. Relevant data are presented in Figure 167, Figure 168, Figure 169 and Table 264 to Table 270.

In Table 271 are presented relevant default factors for estimation of N added to soils from crop residues:

- Dry matter fraction of harvested product (DRY)
- Above-ground residue dry matter AG_{DM}(T)
- AGDM(T) = (Crop(T)/1000)*
- slope(T) +
- intercept(T)
- N content of above-ground residues (NAG)
- Ratio of below- ground residues to above-ground biomass (RBG-BIO)
- N content of below-ground residues (NBG)

[174] FAO (2019): Available on 29.02.2019 at: http://www.fao.org/faostat/en/#data/QC

With the Equation 11.1.a (see also above in 5.5.2.1.1 Choice of methods) and the Equation for conversion N_2O-N tot N_2O the N_2O emissions from N inputs to managed soils

Annual direct N_2O–N emissions from N inputs to managed soils (2006 IPCC GL, Vol. 4, Chap. 11) [167]

$$N_2O - N_{N\,inputs} = [[(F_{CR}) \times EF_1] + [(F_{CR})_{FR} \times EF_{1FR}]] \quad \textbf{(11.1.a)}$$

$$N_2O\ emissions_{direct} = N_2O - N \times \frac{44}{28}$$

Table 262 Nitrous oxide emissions from N Input from annual amount of *N in crop residues, including N-fixing crops, and from forage/pasture renewal, returned to soils (F_{CR})*

Parameter	N in Crop Residues returned to Soils	Emission Factor – N_2O-N	N_2O-N emissions	N_2O emissions from Crop Residues returned to Soils	Method	EF used
Abbreviation	F_{PRP}	EF_3 - N_2O-N	N_2O-N	N_2O		
Unit	t N	kg N_2O-N/kg N	Gg	Gg		
1990	686,063,750	0.01	6.86	10.78	T1	D
1991	703,940,565	0.01	7.04	11.06	T1	D
1992	649,926,104	0.01	6.50	10.21	T1	D
1993	708,819,836	0.01	7.09	11.14	T1	D
1994	763,474,554	0.01	7.63	12.00	T1	D
1995	808,003,625	0.01	8.08	12.70	T1	D
1996	776,996,167	0.01	7.77	12.21	T1	D
1997	882,242,822	0.01	8.82	13.86	T1	D
1998	945,063,794	0.01	9.45	14.85	T1	D
1999	719,972,879	0.01	7.20	11.31	T1	D
2000	538,306,089	0.01	5.38	8.46	T1	D
2001	538,129,705	0.01	5.38	8.46	T1	D
2002	855,275,612	0.01	8.55	13.44	T1	D
2003	976,751,917	0.01	9.77	15.35	T1	D
2004	905,998,490	0.01	9.06	14.24	T1	D
2005	1,146,848,918	0.01	11.47	18.02	T1	D
2006	1,087,287,807	0.01	10.87	17.09	T1	D
2007	1,254,968,971	0.01	12.55	19.72	T1	D
2008	1,074,633,288	0.01	10.75	16.89	T1	D
2009	1,451,602,521	0.01	14.52	22.81	T1	D
2010	1,397,510,916	0.01	13.98	21.96	T1	D
2011	1,239,236,725	0.01	12.39	19.47	T1	D
2012	1,309,383,013	0.01	13.09	20.58	T1	D

Parameter	N in Crop Residues returned to Soils	Emission Factor – N_2O-N	N_2O-N emissions	N_2O emissions from Crop Residues returned to Soils	Method	EF used
Abbreviation	F_{PRP}	EF_3 - N_2O-N	N_2O-N	N_2O		
Unit	t N	kg N_2O-N/kg N	Gg	Gg		
2013	1,344,240,537	0.01	13.44	21.12	T1	D
2014	1,389,164,489	0.01	13.89	21.83	T1	D
2015	1,140,284,709	0.01	11.40	17.92	T1	D
2016	1,047,092,665	0.01	10.47	16.45	T1	D
2017	953,999,919	0.01	9.54	14.99	T1	D

In Table 263 is provided an exemplary calculation of direct N_2O emissions from managed soils (TIER 1) due to annual amount of N in crop residues from wheat returned to soil (F_{CR}).

Table 263 Exemplary calculation of direct N_2O emissions from managed soils (TIER 1) due to annual amount of N in crop residues returned to soil (F_{CR}) – wheat

Parameter	Parameter description	Unit	Formula	Parameter Source	2017
C_f	Combustion factor			Table 2.6, Chap. 2, Vol.4, 2006 IPPC GL, page 2.45	0.9
	Area of **Wheat**	ha		1996-1997, 2000-2017: NSIA Statistical Yearbooks (all years), Table 8-2 and Table 8-4 1990-2017: FAO STAT Crops[174]	1,570,000.00
	Yield fresh of **Wheat**	kg/ha			10,510.00
	Area burnt	ha	Area x 0.05	Expert Judgement; assumption that about 5% of the area is burnt	78,500.00
	Crop	kg d.m./ha	Yeld Fresh x DRY	Equation 11.7, Chap. 11, Vol. 4, 2006 IPCC GL, p. 11.15	9,353.90
DRY	Dry matter fraction	kg d.m./ha		Table 11.2, Chap. 11, Vol. 4, 2006 IPCC GL, p. 11.17	0.89
AG_{DM}	Above-ground residue dry matter	Mg/ha	(Crop/1000) x Slope + Intercept		14.64
	Slope	-			1.51
	Intercept	-			0.52
R_{AG}	Ratio of above-ground residues	kg d.m.	AG_{DM} x 1000/Crop	In explanation to Equation 11.6, Chap. 11, Vol. 4, 2006 IPCC GL, page 11.14	1.57
N_{AG}	N content of above-ground residue for crops	kg d.m.		Table 11.2, Chap. 11, Vol. 4, 2006 IPCC GL, p. 11.17	0.01
R_{BG-BIO}	Ratio of below-ground residues TO above-ground biomass	-			0.24
R_{BG}	Ratio of below-ground residues	kg d.m.	R_{BG-BIO} x (AG_{DM} x 1000 + Crop)/Crop	In explanation to Equation 11.6, Chap. 11, Vol. 4, 2006 IPCC GL, page 11.14	0.62
N_{BG}	N content of below-ground residue for crops	kg d.m.		Table 11.2, Chap. 11, Vol. 4, 2006 IPCC GL, p. 11.17	0.01
F_{CR}	Annual amount of N in crop residue	kg N/yr	(Area-Area burnt x C_f) x AG_{DM} x 1000 x N_{AG} +Area x (AG_{DM} x 1000+Crop) x R_{BG-BIO} x N_{BG}	Equation 11.7A, Chap. 11, Vol.4, 2006 IPCC GL, page 11.15	213,125,386
EF_1 - N_2O-N	Emission Factor - N_2O-N	kg N_2O-N/kg N		Table. 11.1, Chap. 11, Vol. 4, 2006 IPCC GL, p. 11.11 See also Table 258	0.01
N_2O-N	N_2O-N emissions	Gg	(F_{CR} x EF_1) / 1,000,000	Equation 11.1, Chap. 11, Vol. 4, 2006 IPCC GL, p. 11.7	2.13
N_2O	N_2O emissions	Gg	N_2O-N emissions x (44/28)	Equation for conversion, Chap. 11, Vol. 4, 2006 IPCC GL, page 11.10	3.35
N_2O	Method	-	-	-	T1
N_2O	EF used	-	-	-	D

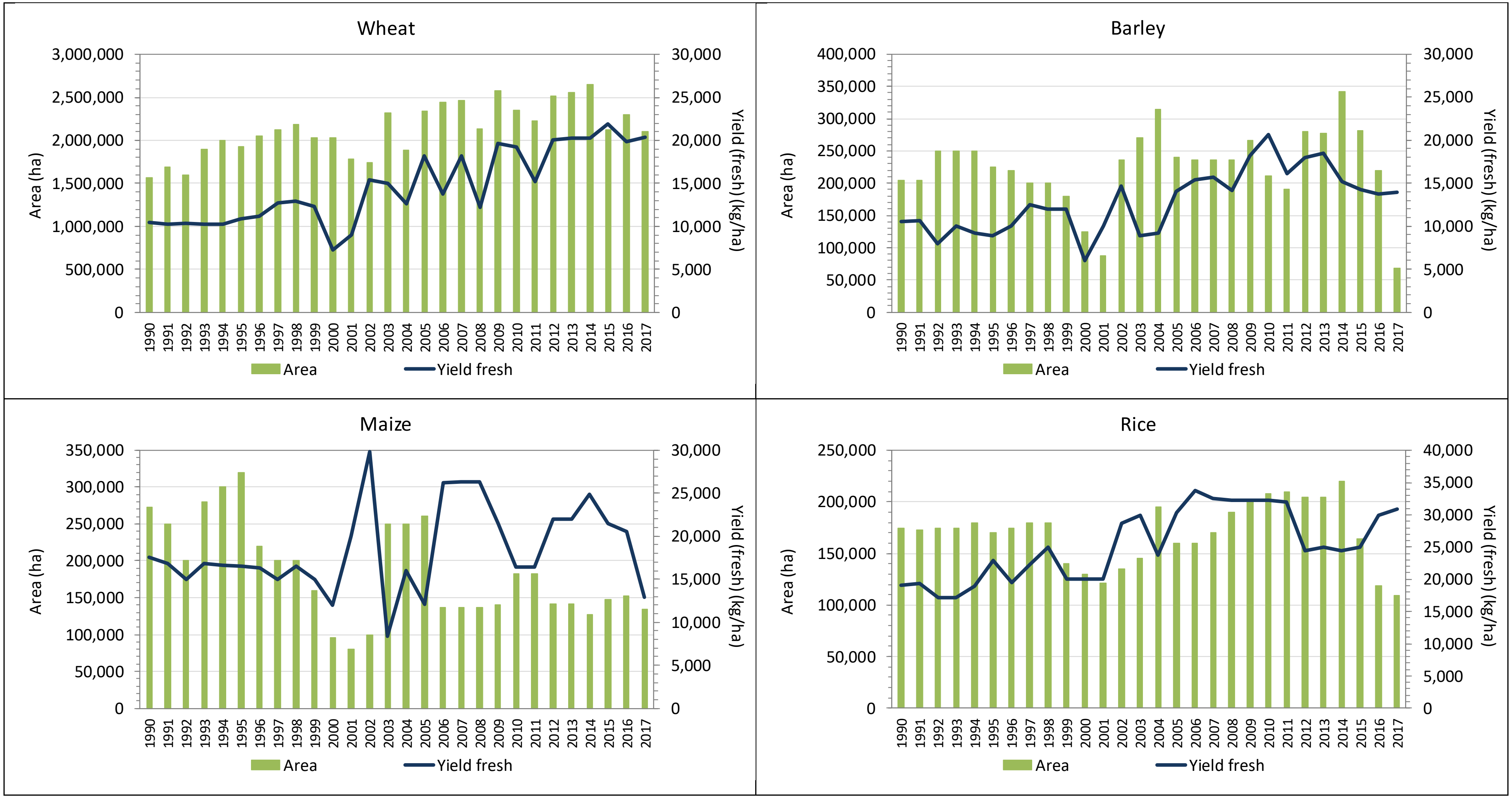


Figure 167 Wheat, barley, maize and rice: area harvested of crops and yield

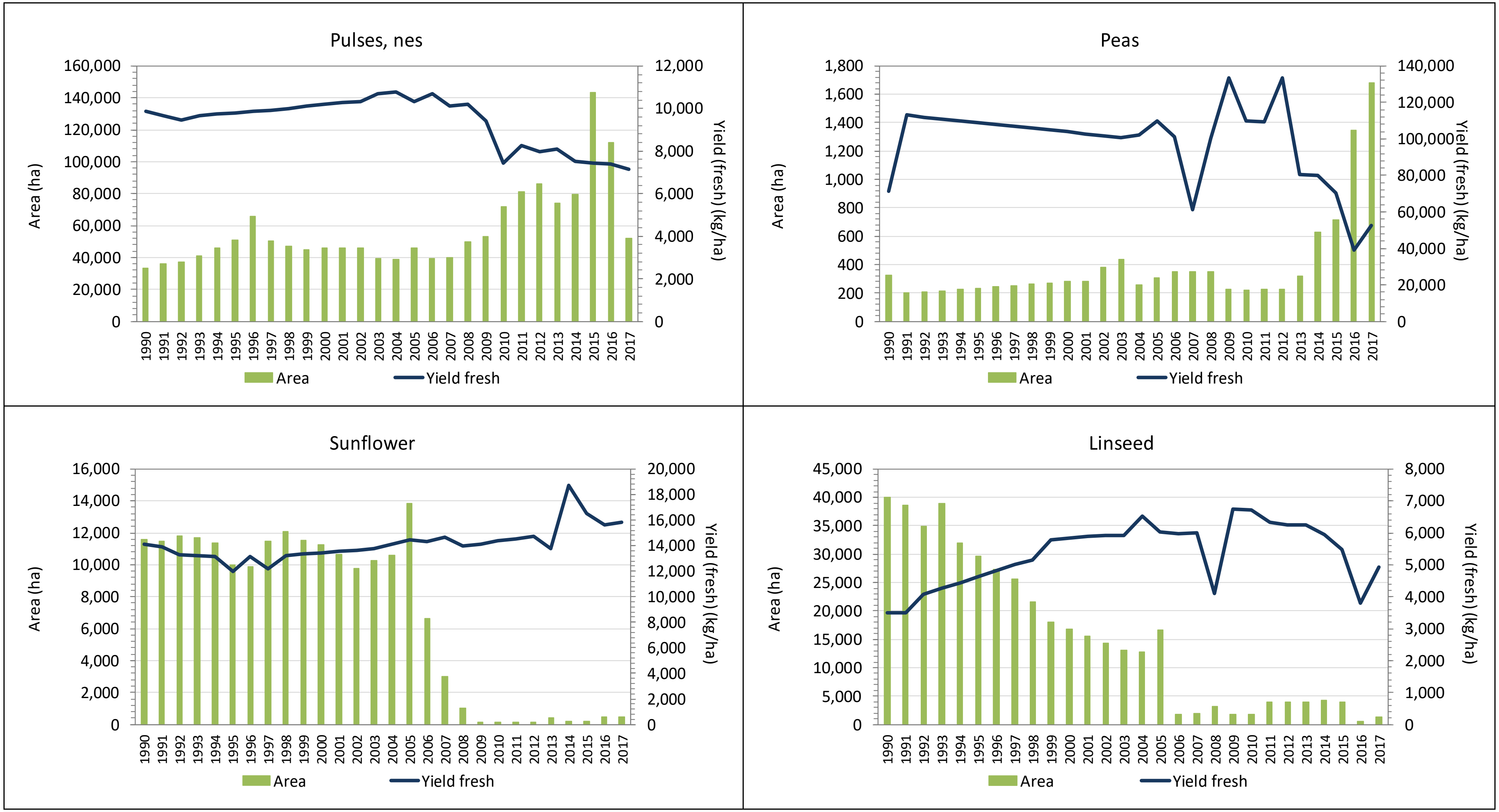


Figure 168 **Pulses, peanuts, sunflower and peas: area harvested of crops and yield**

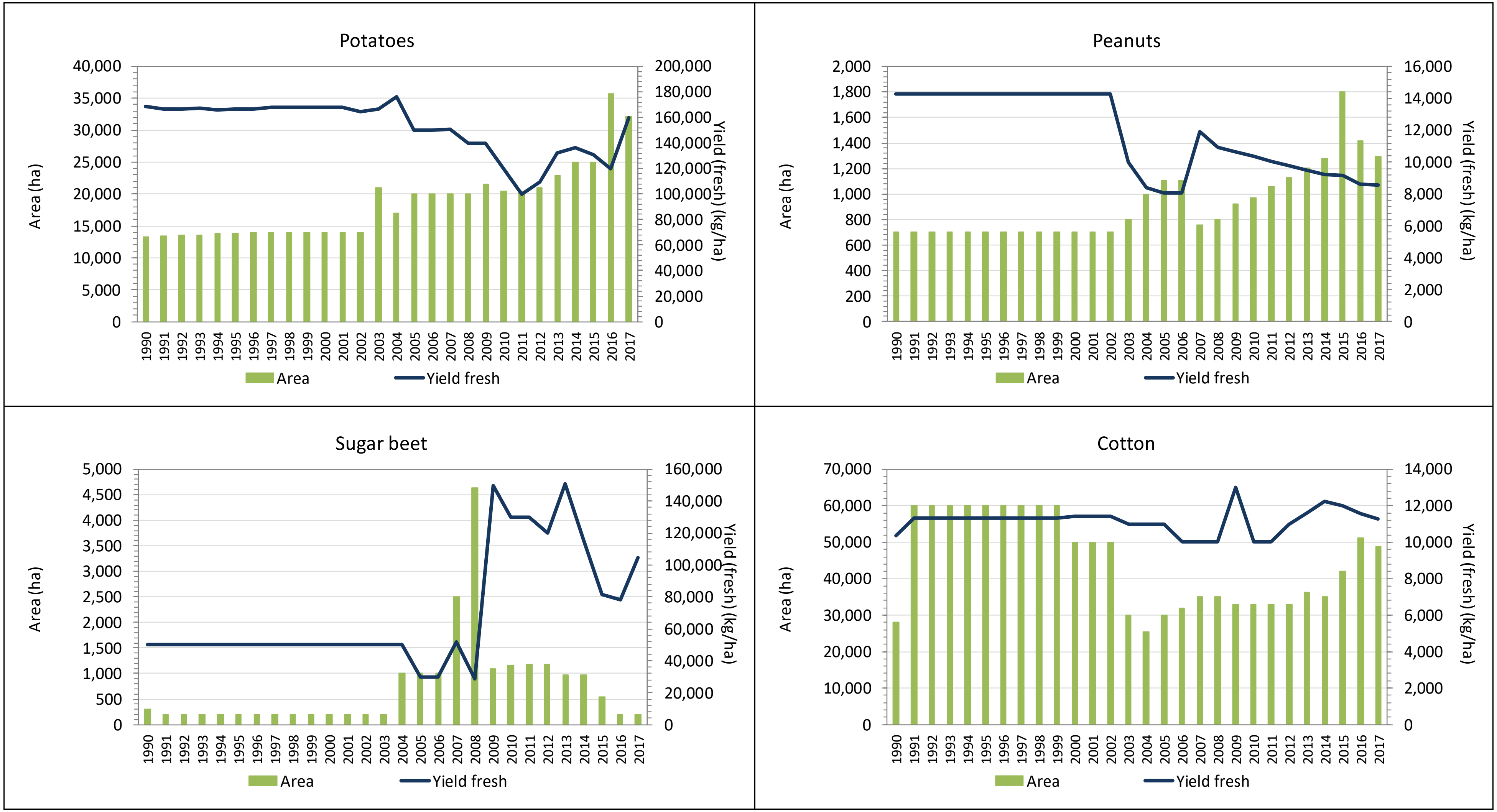


Figure 169 Linseed, potatoes, sugar beet and cotton: area harvested of crops and yield

Table 264 Wheat and Barley: total annual area harvested of crops, yield, burned areas and dry matter fraction

Crop	CEREALS									
	Wheat					Barley				
	Area	Yield fresh	Area burnt (assuming 5% of wheat area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)	Area	Yield fresh	Area burnt (assuming 5% of barley area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)
Unit	ha	kg/ha	ha		kg d.m./ha	ha	kg/ha	ha		kg d.m./ha
1990	1,570,000	10,510	78,500	0.89	9,354	205,000	10,250	9,378	10,537	0.89
1991	1,690,000	10,213	84,500	0.89	9,090	204,000	10,200	9,467	10,637	0.89
1992	1,600,000	10,313	80,000	0.89	9,179	250,000	12,500	7,120	8,000	0.89
1993	1,900,000	10,211	95,000	0.89	9,088	250,000	12,500	8,900	10,000	0.89
1994	2,000,000	10,250	100,000	0.89	9,123	250,000	12,500	8,188	9,200	0.89
1995	1,927,468	10,895	96,373	0.89	9,697	225,000	11,250	7,911	8,889	0.89
1996	2,050,000	11,220	102,500	0.89	9,986	220,000	11,000	8,900	10,000	0.89
1997	2,124,000	12,764	106,200	0.89	11,360	200,000	10,000	11,125	12,500	0.89
1998	2,186,000	12,964	109,300	0.89	11,538	200,000	10,000	10,680	12,000	0.89
1999	2,027,000	12,329	101,350	0.89	10,973	180,000	9,000	10,680	12,000	0.89
2000	2,029,000	7,240	101,450	0.89	6,444	124,000	6,200	5,312	5,968	0.89
2001	1,779,000	8,977	88,950	0.89	7,990	87,000	4,350	8,900	10,000	0.89
2002	1,742,000	15,419	87,100	0.89	13,723	236,000	11,800	13,011	14,619	0.89
2003	2,320,000	15,000	116,000	0.89	13,350	270,000	13,500	7,911	8,889	0.89
2004	1,888,000	12,659	94,400	0.89	11,267	315,000	15,750	8,193	9,206	0.89
2005	2,342,000	18,215	117,100	0.89	16,211	240,000	12,000	12,497	14,042	0.89
2006	2,444,000	13,760	122,200	0.89	12,246	236,000	11,800	13,727	15,424	0.89
2007	2,466,000	18,183	123,300	0.89	16,183	236,000	11,800	13,953	15,678	0.89
2008	2,139,000	12,263	106,950	0.89	10,914	236,000	11,800	12,558	14,110	0.89

Crop	CEREALS									
	Wheat					Barley				
	Area	Yield fresh	Area burnt (assuming 5% of wheat area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)	Area	Yield fresh	Area burnt (assuming 5% of barley area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)
Unit	**ha**	**kg/ha**	**ha**		**kg d.m./ha**	**ha**	**kg/ha**	**ha**		**kg d.m./ha**
2009	2,575,000	19,666	128,750	0.89	17,503	267,000	13,350	16,200	18,202	0.89
2010	2,354,000	19,252	117,700	0.89	17,134	212,000	10,600	18,346	20,613	0.89
2011	2,232,000	15,179	111,600	0.89	13,509	190,000	9,500	14,329	16,100	0.89
2012	2,512,000	20,104	125,600	0.89	17,893	280,000	14,000	16,020	18,000	0.89
2013	2,552,922	20,248	127,646	0.89	18,021	278,000	13,900	16,455	18,489	0.89
2014	2,653,746	20,237	132,687	0.89	18,011	342,472	17,124	13,540	15,213	0.89
2015	2,128,104	21,959	106,405	0.89	19,544	282,000	14,100	12,719	14,291	0.89
2016	2,300,210	19,803	115,011	0.89	17,625	219,208	10,960	12,255	13,770	0.89
2017	2,104,377	20,342	105,219	0.89	18,104	68,179	3,409	12,400	13,933	0.89
Source	1996-1997, 2000-2017: NSIA Statistical Yearbooks (all years), Table 8-2 and Table 8-4 1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7	1996-1997, 2000-2017: NSIA Statistical Yearbooks (all years), Table 8-2 and Table 8-4 1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7

Table 265 Maize and Rice: total annual area harvested of crops, yield, burned areas and dry matter fraction

Crop	CEREALS									
	Maize					Rice				
	Area	Yield fresh	Area burnt (assuming 5% of Maize area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)	Area	Yield fresh	Area burnt (assuming 5% of Rice area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)
Unit	ha	kg/ha	ha		kg d.m./ha	ha	kg/ha	ha		kg d.m./ha
1990	273,000	17,582	13,650	0.87	15,296	175,000	19,029	8,750	0.89	16,936
1991	250,000	16,800	12,500	0.87	14,616	173,000	19,364	8,650	0.89	17,234
1992	200,000	15,000	10,000	0.87	13,050	175,000	17,143	8,750	0.89	15,257
1993	280,000	16,786	14,000	0.87	14,604	175,000	17,143	8,750	0.89	15,257
1994	300,000	16,667	15,000	0.87	14,500	180,000	19,000	9,000	0.89	16,910
1995	320,000	16,563	16,000	0.87	14,410	170,000	22,941	8,500	0.89	20,417
1996	220,000	16,364	11,000	0.87	14,237	175,000	19,429	8,750	0.89	17,292
1997	200,000	15,000	10,000	0.87	13,050	180,000	22,222	9,000	0.89	19,778
1998	200,000	16,500	10,000	0.87	14,355	180,000	25,000	9,000	0.89	22,250
1999	160,000	15,000	8,000	0.87	13,050	140,000	20,000	7,000	0.89	17,800
2000	96,000	11,979	4,800	0.87	10,422	130,000	20,000	6,500	0.89	17,800
2001	80,000	20,000	4,000	0.87	17,400	121,000	20,000	6,050	0.89	17,800
2002	100,000	29,800	5,000	0.87	25,926	135,000	28,741	6,750	0.89	25,579
2003	250,000	8,400	12,500	0.87	7,308	145,000	29,931	7,250	0.89	26,639
2004	250,000	16,000	12,500	0.87	13,920	195,000	23,744	9,750	0.89	21,132
2005	261,000	12,069	13,050	0.87	10,500	160,000	30,313	8,000	0.89	26,979
2006	137,000	26,204	6,850	0.87	22,797	160,000	33,750	8,000	0.89	30,038
2007	137,000	26,277	6,850	0.87	22,861	170,000	32,471	8,500	0.89	28,899
2008	137,000	26,277	6,850	0.87	22,861	190,000	32,211	9,500	0.89	28,668
2009	140,000	21,429	7,000	0.87	18,643	200,000	32,250	10,000	0.89	28,703

Crop	CEREALS									
	Maize					Rice				
	Area	Yield fresh	Area burnt (assuming 5% of Maize area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)	Area	Yield fresh	Area burnt (assuming 5% of Rice area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)
Unit	**ha**	**kg/ha**	**ha**		**kg d.m./ha**	**ha**	**kg/ha**	**ha**		**kg d.m./ha**
2010	183,000	16,448	9,150	0.87	14,310	208,000	32,308	10,400	0.89	28,754
2011	183,000	16,400	9,150	0.87	14,268	210,000	32,000	10,500	0.89	28,480
2012	141,000	21,986	7,050	0.87	19,128	205,000	24,390	10,250	0.89	21,707
2013	142,000	21,972	7,100	0.87	19,116	205,000	24,980	10,250	0.89	22,232
2014	127,000	24,882	6,350	0.87	21,647	220,000	24,409	11,000	0.89	21,724
2015	147,273	21,457	7,364	0.87	18,668	164,000	25,000	8,200	0.89	22,250
2016	151,900	20,517	7,595	0.87	17,850	119,000	29,963	5,950	0.89	26,667
2017	134,225	12,957	6,711	0.87	11,273	109,452	30,919	5,473	0.89	27,518
Source	1996-1997, 2000-2017: NSIA Statistical Yearbooks (all years), Table 8-2 and Table 8-4 1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7	1996-1997, 2000-2017: NSIA Statistical Yearbooks (all years), Table 8-2 and Table 8-4 1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7

Table 266 Pulses and peas: total annual area harvested of crops, yield, burned areas and dry matter fraction

Crop	PULSES									
	Pulses, nes					Peas				
	Area	Yield fresh	Area burnt (assuming 5% of Pulses area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)	Area	Yield fresh	Area burnt (assuming 5% of Pea area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)
Unit	ha	kg/ha	ha		kg d.m./ha	ha	kg/ha	ha		kg d.m./ha
1990	33,465	9,861	1,673	0.85	8,382	323	71,084	16	0.91	64,686
1991	36,000	9,667	1,800	0.85	8,217	202	113,002	10	0.91	102,832
1992	37,000	9,459	1,850	0.85	8,040	208	111,985	10	0.91	101,906
1993	41,329	9,678	2,066	0.85	8,226	215	110,967	11	0.91	100,980
1994	46,279	9,724	2,314	0.85	8,265	225	109,950	11	0.91	100,055
1995	51,116	9,782	2,556	0.85	8,315	234	108,932	12	0.91	99,128
1996	65,982	9,851	3,299	0.85	8,373	243	107,915	12	0.91	98,203
1997	50,377	9,925	2,519	0.85	8,436	253	106,897	13	0.91	97,276
1998	47,041	9,997	2,352	0.85	8,497	262	105,880	13	0.91	96,351
1999	44,730	10,110	2,237	0.85	8,594	272	104,862	14	0.91	95,424
2000	46,079	10,203	2,304	0.85	8,673	282	103,844	14	0.91	94,498
2001	46,119	10,262	2,306	0.85	8,723	284	102,827	14	0.91	93,573
2002	46,124	10,317	2,306	0.85	8,769	379	101,809	19	0.91	92,646
2003	39,300	10,712	1,965	0.85	9,105	435	100,792	22	0.91	91,721
2004	39,000	10,769	1,950	0.85	9,154	256	102,216	13	0.91	93,017
2005	46,065	10,342	2,303	0.85	8,791	305	109,712	15	0.91	99,838
2006	39,300	10,712	1,965	0.85	9,105	350	101,143	18	0.91	92,040
2007	40,000	10,126	2,000	0.85	8,607	350	61,286	18	0.91	55,770
2008	50,000	10,200	2,500	0.85	8,670	350	100,000	18	0.91	91,000
2009	53,000	9,434	2,650	0.85	8,019	225	133,333	11	0.91	121,333

Crop	PULSES									
	Pulses, nes					Peas				
	Area	Yield fresh	Area burnt (assuming 5% of Pulses area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)	Area	Yield fresh	Area burnt (assuming 5% of Pea area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)
Unit	**ha**	**kg/ha**	**ha**		**kg d.m./ha**	**ha**	**kg/ha**	**ha**		**kg d.m./ha**
2010	71,700	7,434	3,585	0.85	6,319	220	109,938	11	0.91	100,044
2011	81,000	8,272	4,050	0.85	7,031	225	109,117	11	0.91	99,296
2012	86,368	7,989	4,318	0.85	6,791	225	133,333	11	0.91	121,333
2013	74,113	8,096	3,706	0.85	6,882	319	80,439	16	0.91	73,199
2014	79,746	7,524	3,987	0.85	6,395	632	80,000	32	0.91	72,800
2015	143,555	7,443	7,178	0.85	6,327	717	70,544	36	0.91	64,195
2016	111,894	7,406	5,595	0.85	6,295	1,346	38,826	67	0.91	35,332
2017	52,243	7,137	2,612	0.85	6,066	1,680	52,750	84	0.91	48,003
Source	1996-1997, 2000-2017: NSIA Statistical Yearbooks (all years), Table 8-2 and Table 8-4 1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7	1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7

Table 267 Linseed and berries: total annual area harvested of crops, yield, burned areas and dry matter fraction

Crop	Linseed					Berries, nes				
	Area	Yield fresh	Area burnt (assuming 5% of linseed area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)	Area	Yield fresh	Area burnt (assuming 5% of berries area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)
Unit	ha	kg/ha	ha		kg d.m./ha	ha	kg/ha	ha		kg d.m./ha
1990	40,000	3,500	2,000	0.18	630	6,671	85,280	334	0.91	77,605
1991	38,600	3,497	1,930	0.18	629	9,274	112,749	464	0.91	102,602
1992	34,842	4,084	1,742	0.18	735	9,079	110,971	454	0.91	100,984
1993	39,000	4,263	1,950	0.18	767	8,877	109,194	444	0.91	99,367
1994	32,011	4,446	1,601	0.18	800	8,668	107,417	433	0.91	97,749
1995	29,590	4,632	1,480	0.18	834	8,453	105,640	423	0.91	96,132
1996	27,377	4,817	1,369	0.18	867	8,230	103,863	412	0.91	94,515
1997	25,579	4,997	1,279	0.18	899	7,999	102,086	400	0.91	92,898
1998	21,615	5,160	1,081	0.18	929	7,760	100,308	388	0.91	91,280
1999	18,021	5,779	901	0.18	1,040	7,513	98,531	376	0.91	89,663
2000	16,825	5,837	841	0.18	1,051	7,256	96,754	363	0.91	88,046
2001	15,511	5,883	776	0.18	1,059	6,990	94,977	350	0.91	86,429
2002	14,289	5,914	714	0.18	1,065	6,714	93,200	336	0.91	84,812
2003	13,152	5,929	658	0.18	1,067	6,226	93,351	311	0.91	84,949
2004	12,750	6,510	638	0.18	1,172	6,346	85,857	317	0.91	78,130
2005	16,588	6,028	829	0.18	1,085	6,000	85,000	300	0.91	77,350
2006	1,840	5,978	92	0.18	1,076	5,000	85,000	250	0.91	77,350
2007	2,000	6,000	100	0.18	1,080	5,586	85,929	279	0.91	78,195
2008	3,160	4,114	158	0.18	741	5,500	85,455	275	0.91	77,764
2009	1,780	6,742	89	0.18	1,214	3,800	85,000	190	0.91	77,350
2010	1,788	6,711	89	0.18	1,208	3,800	78,328	190	0.91	71,278

Crop	Linseed					Berries, nes				
	Area	Yield fresh	Area burnt (assuming 5% of linseed area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)	Area	Yield fresh	Area burnt (assuming 5% of berries area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)
Unit	ha	kg/ha	ha		kg d.m./ha	ha	kg/ha	ha		kg d.m./ha
2011	3,943	6,340	197	0.18	1,141	3,800	72,735	190	0.91	66,189
2012	4,000	6,250	200	0.18	1,125	3,800	65,789	190	0.91	59,868
2013	4,000	6,250	200	0.18	1,125	3,800	65,789	190	0.91	59,868
2014	4,213	5,934	211	0.18	1,068	3,800	62,002	190	0.91	56,422
2015	3,891	5,480	195	0.18	986	3,800	64,036	190	0.91	58,273
2016	577	3,787	29	0.18	682	3,800	63,005	190	0.91	57,335
2017	1,395	4,924	70	0.18	886	3,800	61,030	190	0.91	55,537
Source	1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7	1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7

Table 268 Potatoes: **total annual area harvested of crops, yield, burned areas and dry matter fraction**

	TUBERS					ROOT CROPS				
Crop	**Potatoes**					**Peanuts**				
	Area	**Yield fresh**	**Area burnt (assuming 5% of potatoes area)**	**Dry matter (d.m.) fraction (DRY)**	**Harvested dry matter yield (Yield fresh x DRY)**	**Area**	**Yield fresh**	**Area burnt (assuming 5% of sugar beet area)**	**Dry matter (d.m.) fraction (DRY)**	**Harvested dry matter yield (Yield fresh x DRY)**
Unit	**ha**	**kg/ha**	**ha**		**kg d.m./ha**	**ha**	**kg/ha**	**ha**		**kg d.m./ha**
1990	13,300	168,421	665	0.22	37,053	700	14,286	35	0.94	13,429
1991	13,400	166,418	670	0.22	36,612	700	14,286	35	0.94	13,429
1992	13,500	166,667	675	0.22	36,667	700	14,286	35	0.94	13,429
1993	13,600	166,912	680	0.22	36,721	700	14,286	35	0.94	13,429
1994	13,800	165,942	690	0.22	36,507	700	14,286	35	0.94	13,429
1995	13,900	166,187	695	0.22	36,561	700	14,286	35	0.94	13,429
1996	14,000	166,429	700	0.22	36,614	700	14,286	35	0.94	13,429
1997	14,000	167,857	700	0.22	36,929	700	14,286	35	0.94	13,429
1998	14,000	167,857	700	0.22	36,929	700	14,286	35	0.94	13,429
1999	14,000	167,857	700	0.22	36,929	700	14,286	35	0.94	13,429
2000	14,000	167,857	700	0.22	36,929	700	14,286	35	0.94	13,429
2001	14,000	167,857	700	0.22	36,929	700	14,286	35	0.94	13,429
2002	14,000	164,286	700	0.22	36,143	700	14,286	35	0.94	13,429
2003	21,000	166,667	1,050	0.22	36,667	800	10,000	40	0.94	9,400
2004	17,000	176,471	850	0.22	38,824	1,000	8,400	50	0.94	7,896
2005	20,000	150,000	1,000	0.22	33,000	1,105	8,081	55	0.94	7,596
2006	20,000	150,000	1,000	0.22	33,000	1,105	8,081	55	0.94	7,596
2007	20,000	150,400	1,000	0.22	33,088	755	11,921	38	0.94	11,206
2008	20,000	140,000	1,000	0.22	30,800	800	10,909	40	0.94	10,254
2009	21,600	140,000	1,080	0.22	30,800	922	10,630	46	0.94	9,992

	TUBERS					ROOT CROPS				
Crop	Potatoes					Peanuts				
	Area	Yield fresh	Area burnt (assuming 5% of potatoes area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)	Area	Yield fresh	Area burnt (assuming 5% of sugar beet area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)
Unit	ha	kg/ha	ha		kg d.m./ha	ha	kg/ha	ha		kg d.m./ha
2010	20,500	120,000	1,025	0.22	26,400	969	10,356	48	0.94	9,735
2011	20,500	100,000	1,025	0.22	22,000	1,057	10,060	53	0.94	9,456
2012	21,000	109,524	1,050	0.22	24,095	1,127	9,778	56	0.94	9,191
2013	22,960	131,960	1,148	0.22	29,031	1,202	9,498	60	0.94	8,928
2014	25,009	136,054	1,250	0.22	29,932	1,282	9,217	64	0.94	8,664
2015	25,019	130,903	1,251	0.22	28,799	1,800	9,167	90	0.94	8,617
2016	35,699	119,868	1,785	0.22	26,371	1,415	8,617	71	0.94	8,100
2017	32,116	159,794	1,606	0.22	35,155	1,296	8,578	65	0.94	8,063
Source	1996-1997, 2000-2017: NSIA Statistical Yearbooks (all years), Table 8-2 and Table 8-4 1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7	1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7

Table 269 **Cotton and sugar beet: total annual area harvested of crops, yield, burned areas and dry matter fraction**

	NON N-FIXING CROP									
Crop	Cotton					Sugar beet				
	Area	Yield fresh	Area burnt (assuming 5% of cotton area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)	Area	Yield fresh	Area burnt (assuming 5% of sugar beet area)	Dry matter (d.m.) fraction (DRY)	Harvested dry matter yield (Yield fresh x DRY)
Unit	ha	kg/ha	ha		kg d.m./ha	ha	kg/ha	ha		kg d.m./ha
1990	28,000	10,357	1,400	0.85	8,803	300	50,000	15	0.90	35,000
1991	60,000	11,333	3,000	0.85	9,633	200	50,000	10	0.90	35,000
1992	60,000	11,333	3,000	0.85	9,633	200	50,000	10	0.90	35,000
1993	60,000	11,333	3,000	0.85	9,633	200	50,000	10	0.90	35,000
1994	60,000	11,333	3,000	0.85	9,633	200	50,000	10	0.90	35,000
1995	60,000	11,333	3,000	0.85	9,633	200	50,000	10	0.90	35,000
1996	60,000	11,333	3,000	0.85	9,633	200	50,000	10	0.90	35,000
1997	60,000	11,333	3,000	0.85	9,633	200	50,000	10	0.90	35,000
1998	60,000	11,333	3,000	0.85	9,633	200	50,000	10	0.90	35,000
1999	60,000	11,333	3,000	0.85	9,633	200	50,000	10	0.90	35,000
2000	50,000	11,400	2,500	0.85	9,690	200	50,000	10	0.90	35,000
2001	50,000	11,400	2,500	0.85	9,690	200	50,000	10	0.90	35,000
2002	50,000	11,400	2,500	0.85	9,690	200	50,000	10	0.90	35,000
2003	30,000	11,000	1,500	0.85	9,350	200	50,000	10	0.90	35,000
2004	25,500	10,980	1,275	0.85	9,333	1,000	50,000	50	0.90	35,000
2005	30,000	11,000	1,500	0.85	9,350	1,000	30,000	50	0.90	21,000
2006	31,950	10,016	1,598	0.85	8,514	1,000	30,000	50	0.90	21,000
2007	35,000	10,015	1,750	0.85	8,513	2,500	51,752	125	0.90	36,226
2008	35,000	10,000	1,750	0.85	8,500	4,640	28,698	232	0.90	20,089
2009	33,000	12,992	1,650	0.85	11,043	1,100	150,000	55	0.90	105,000

	NON N-FIXING CROP									
Crop	**Cotton**					**Sugar beet**				
	Area	**Yield fresh**	**Area burnt (assuming 5% of cotton area)**	**Dry matter (d.m.) fraction (DRY)**	**Harvested dry matter yield (Yield fresh x DRY)**	**Area**	**Yield fresh**	**Area burnt (assuming 5% of sugar beet area)**	**Dry matter (d.m.) fraction (DRY)**	**Harvested dry matter yield (Yield fresh x DRY)**
Unit	**ha**	**kg/ha**	**ha**		**kg d.m./ha**	**ha**	**kg/ha**	**ha**		**kg d.m./ha**
2010	33,000	10,000	1,650	0.85	8,500	1,170	129,915	59	0.90	90,941
2011	33,000	10,000	1,650	0.85	8,500	1,172	130,000	59	0.90	91,000
2012	33,000	11,000	1,650	0.85	9,350	1,172	120,000	59	0.90	84,000
2013	36,300	11,618	1,815	0.85	9,875	980	150,663	49	0.90	105,464
2014	35,000	12,237	1,750	0.85	10,401	980	115,612	49	0.90	80,928
2015	42,124	11,984	2,106	0.85	10,186	551	81,579	28	0.90	57,105
2016	51,102	11,545	2,555	0.85	9,813	202	78,317	10	0.90	54,822
2017	48,688	11,286	2,434	0.85	9,593	201	104,577	10	0.90	73,204
Source	1996-1997, 2000-2017: NSIA Statistical Yearbooks (all years), Table 8-2 and Table 8-4 1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7	1996-1997, 2000-2017: NSIA Statistical Yearbooks (all years), Table 8-2 and Table 8-4 1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7

Table 270 Sunflower: total annual area harvested of crops, yield, burned areas and dry matter fraction

	NON N-FIXING CROP				
Crop	**Sunflower**				
	Area	**Yield fresh**	**Area burnt (assuming 5% of sunflower area)**	**Dry matter (d.m.) fraction (DRY)**	**Harvested dry matter yield (Yield fresh x DRY)**
Unit	**ha**	**kg/ha**	**ha**		**kg d.m./ha**
1990	11,600	14,138	580	0.90	12,724
1991	11,500	13,913	575	0.90	12,522
1992	11,801	13,316	590	0.90	11,984
1993	11,698	13,243	585	0.90	11,919
1994	11,386	13,175	569	0.90	11,858
1995	10,000	12,000	500	0.90	10,800
1996	9,876	13,163	494	0.90	11,847
1997	11,500	12,174	575	0.90	10,957
1998	12,081	13,244	604	0.90	11,920
1999	11,511	13,339	576	0.90	12,005
2000	11,271	13,437	564	0.90	12,093
2001	10,633	13,537	532	0.90	12,183
2002	9,766	13,653	488	0.90	12,288
2003	10,254	13,756	513	0.90	12,380
2004	10,625	14,118	531	0.90	12,706
2005	13,824	14,468	691	0.90	13,021
2006	6,630	14,329	332	0.90	12,896
2007	3,000	14,667	150	0.90	13,200
2008	1,000	14,000	50	0.90	12,600
2009	170	14,118	9	0.90	12,706
2010	170	14,412	9	0.90	12,971
2011	170	14,529	9	0.90	13,076
2012	170	14,706	9	0.90	13,235
2013	407	13,759	20	0.90	12,383
2014	210	18,714	11	0.90	16,843
2015	210	16,549	11	0.90	14,894
2016	493	15,617	25	0.90	14,055
2017	457	15,807	23	0.90	14,226
Source	1996-1997, 2000-2017: NSIA Statistical Yearbooks (all years), Table 8-2 and Table 8-4 1990-2017: FAO STAT Crops[174]		Expert Judgement	2006 IPCC GL, Vol. 4, Chap. 11, Table 11.2	2006 IPCC GL, Vol. 4, Chap. 11, Equation 11.7

Table 271 Default factors for estimation of N added to soils from crop residues

Crop	Dry matter fraction of harvested product (DRY)	Above-ground residue dry matter AGDM(T) (Mg/ha): AGDM(T) = (Crop(T)/1000)* slope(T) + intercept(T)		N content of above-ground residues (N_{AG})	Ratio of below- ground residues to above-ground biomass (R_{BG-BIO})	N content of below-ground residues (N_{BG})
		Slope	Intercept			
Major crop types						
Grains	0.88	1.09	0.88	0.006	0.22	0.009
Beans & pulses	0.91	1.13	0.85	0.008	0.19	0.008
Tubers	0.22	0.10	1.06	0.019	0.20	0.014
Root crops, other	0.94	1.07	1.54	0.016	0.20	0.014
N-fixing forages	0.90	0.3	0	0.027	0.40	0.022
Non-N-fixing forages	0.90	0.3	0	0.015	0.54	0.012
Perennial grasses	0.90	0.3	0	0.015	0.80	0.012
Grass-clover mixtures	0.90	0.3	0	0.025	0.80	0.016
Individual crops						
Maize	0.87	1.03	0.61	0.006	0.22	0.007
Wheat	0.89	1.51	0.52	0.006	0.24	0.009
Winter wheat	0.89	1.61	0.40	0.006	0.23	0.009
Spring wheat	0.89	1.29	0.75	0.006	0.28	0.009
Rice	0.89	0.95	2.46	0.007	0.16	NA
Barley	0.89	0.98	0.59	0.007	0.22	0.014
Oats	0.89	0.91	0.89	0.007	0.25	0.008
Millet	0.90	1.43	0.14	0.007	NA	NA
Sorghum	0.89	0.88	1.33	0.007	NA	0.006
Rye	0.88	1.09	0.88	0.005	NA	0.011
Source: 2006 IPCC Guidelines, Vol. 4, Chap. 11.2.1.3, Table 11.2, page 11.17.						

5.5.2.1.2.4 AD and calculation for N Input from *Mineralised N (F_{SOM})*

Activity data, parameter and emission calculation for N Input from *Mineralised N resulting from loss of soil organic C stocks in mineral soils through land-use change or management practices (F_{SOM})*

The term F_{SOM} refers to the amount of N mineralised from loss in soil organic C in mineral soils through land use change or management practices.

According to 2006 IPCC GL, Vol. 4, Chap. 2[175], land-use change, and a variety of management practices can have a significant impact on soil organic C storage. Organic C and N are intimately linked in soil organic matter. Where soil C is lost through oxidation as a result of land-use or management change, this loss will be accompanied by a simultaneous mineralisation of N. Where a loss of soil C occurs, this mineralised N is regarded as an additional source of N available for conversion to N_2O; just as mineral N released from decomposition of crop residues, for example, becomes a source.

The emissions by sources and removals by sinks were not estimated in this inventory cycle (see Chapter 6). However, the methodology, data and parameter are presented for estimating changes and release in N supply from mineralisation due to land use change, where soil C losses occur. See here also the planned improvement in chapter 5.5.7.

For estimating changes and release in N supply from mineralisation due to land use change, where soil C losses occur (as calculated in 2006 IPCC GL, Vol. 4, Chap 2, Equation 2.25[176]), the Tier 1 method can be applied in 3 steps:

Step 1: Calculate the average annual loss of soil C ($\Delta C_{Mineral,\,LU}$) for the area, over the inventory period, using Equation 2.25. Using the Tier 1 approach, the value for $\Delta C_{Mineral,\,LU}$ will have a single value for all land-uses and management systems.

Equation 2.24 Annual change in organic carbon stocks in mineral soils[176]
(2006 IPCC GL, Vol. 4, Chap. 2)

$$\Delta C_{\text{Mineral}} = \frac{SOC_0 - SOC_{(0-T)}}{D}$$

with

$$SOC = \sum_{c,s,i} \left(SOC_{REFc,s,i} \times F_{LUc,s,i} \times F_{MGc,s,i} \times F_{Ic,s,i} \times A_{c,s,i} \right)$$

Where:

$\Delta C_{Mineral}$ = annual change in carbon stocks in mineral soils (tonnes C $^{yr-1}$)

SOC_0 = soil organic carbon stock in the last year of an inventory time period (tonnes C)

$SOC_{(0-T)}$ = soil organic carbon stock at the beginning of the inventory time period (tonnes C)

SOC_0 and $SOC_{(0-T)}$ are calculated using the SOC equation in the box where the reference carbon stocks, and stock change factors are assigned according to the land-use and management activities and corresponding areas at each of the points in time (time = 0 and time = 0-T)

[175] 2006 IPCC GL, Vol. 4 AFOLU, Chap 2 Generic Methodologies Applicable to Multiple Land-Use Categories, Section 2.3.3 Change in carbon stocks in soils. Page 2.28

[176] 2006 IPCC GL, Vol. 4 AFOLU, Chap 2 Generic Methodologies Applicable to Multiple Land-Use Categories, Section 2.3.3.1 Soil C estimation methods. Equation 2.25 Annual change in organic carbon stocks in mineral soils. Page 2.30.

T = number of years over a single inventory time period, yr

D = Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr. Commonly 20 years, but depends on assumptions made in computing the factors FLU, FMG and FI. If T exceeds D, use the value for T to obtain an annual rate of change over the inventory time period (0-T years).

c = represents the climate zones, s the soil types, and i the set of management systems that are present.

SOC_{REF} = the reference carbon stock (tonnes C ha-1)

F_{LU} = stock change factor for land-use systems or sub-system for a particular land-use, dimensionless

F_{MG} = stock change factor for management regime, dimensionless

F_I = stock change factor for input of organic matter, dimensionless

A = land area of the stratum being estimated (ha)

Step 2: Estimate the N mineralised as a consequence of this loss of soil C (F_{SOM}), using Equation 11.8[177]:

Equation 11.8 N mineralized in mineral soils as a result of loss of soil c through change in land use or management (TIER1)

(2006 IPCC GL, Vol. 4, Chap. 11)

$$F_{SOM} = \sum_{LU} \left[\left(\Delta C_{Mineral,LU} \times \frac{1}{R} \right) \times 1000 \right]$$

Where:

F_{SOM} = the net annual amount of N mineralised in mineral soils as a result of loss of soil carbon through change in land use or management, kg N

$\Delta C_{Mineral, LU}$ = average annual loss of soil carbon for each land-use type (LU), tonnes C

Note: for Tier 1, $\Delta C_{mineral, LU}$ will have a single value for all land-uses and management systems.

R = C:N ratio of the soil organic matter.

A default value of 15 for the C:N ratio (R) may be used for situations involving land-use change from Forest Land or Grassland to Cropland, in the absence of more specific data for the area.

A default value of 10 may be used for situations involving management changes on Cropland Remaining Cropland. C:N ratio can change over time, land use, or management practice.

LU = land-use and/or management system type

Step 3: For Tier 1, the value for F_{SOM} is calculated in a single step.

In the following table is presented the exemplary calculation of direct N_2O emissions from managed soils (TIER 1) due to mineralised N resulting from loss of soil organic C stocks in mineral soils through land-use change or management practices (F_{SOM}).

[177] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap 11.2.1.3 Choice of activity data. Equation 11.8, Page 11.16.

Table 272 Exemplary calculation of direct N_2O emissions from managed soils (TIER 1) due to mineralised N resulting from loss of soil organic C stocks in mineral soils through land-use change or management practices (F_{SOM})

Parameter	Parameter description	Unit	Formula	Parameter Source	2017
A_1	Perennials converted to annual crops	kha	-	From calculation in sector LULUCF	NE
SOC_0	Soil C after 20 years of LUC	t C/ha	-		NE
$SOC_{(0-T)}$	Soil C stock before LUC	t C/ha	-		NE
A_2	Annual croplands converted to perennials	kha	-		NE
SOC_0	Soil C after 20 years of LUC	t C/ha	-		NE
$SOC_{(0-T)}$	Soil C stock before LUC	t C/ha	-		NE
$\Delta C_{Mineral\ LUC-1}$	Net carbon stock change in soils	t C	$\Delta C_{mineral,\ LU}$ = (SOC_0 - $SOC_{(0-T)}$) / D	Equation 2.25, Chap. 2.3.3.1, Vol. 4, 2006 IPCC GL, p. 2.29	NE
$\Delta C_{Mineral\ LUC-2}$	Net carbon stock change in soils	t C	$\Delta C_{mineral,\ LU}$ = (SOC_0 - $SOC_{(0-T)}$) / D		NE
sum					NE
R	C:N ratio of soil organic matter			Explanation to Equation 11.8, Chap. 11.2.1.3, Vol. 4, 2006 IPCC GL, p. 11.16	10
F_{SOM}	Annual amount of N mineralised in mineral soils	kg N	($\Delta C_{mineral,\ LU}$ * 1/R) * 1000	Equation 11.8, Chap. 11.2.1.3, Vol. 4, 2006 IPCC GL, p. 11.16	NE
EF_1 - N_2O-N	Emission Factor - N_2O-N	kg N_2O-N/kg N	-	Table. 11.1, Chap. 11, Vol. 4, 2006 IPCC GL, p. 11.11 See also Table 258	0.01
N_2O-N	N_2O-N emissions	Gg	F_{SOM}*EF1	Equation 11.1, Chap. 11, Vol. 4, 2006 IPCC GL, p. 11.7	NE
N_2O	N_2O emissions	Gg	N_2O - N*44/28	Equation for conversion, Chap. 11, Vol. 4, 2006 IPCC GL, page 11.10	NE
N_2O	Method	-	-	-	T1
N_2O	EF used	-	-	-	D

5.5.2.1.2.5 AD and calculation for N Input from *area of drained/managed organic soils (F_{OS})*

Activity data, parameter and emission calculation for *N Input from area of drained/managed organic soils (FOS)*

The term F_{OS} refers to the total annual area (ha) of drained/managed organic soils (see footnote 4 for definition). This definition is applicable for both the Tier 1 and Tier 2 methods. For all land uses, the areas should be stratified by climate zone (temperate and tropical). In addition, for temperate Forest Land the areas should be further stratified by soil fertility (nutrient rich and nutrient poor). The area of drained/managed organic soils (FOS) may be collected from official national statistics. Alternatively, total areas of organic soils from each country are available from FAO (http://faostat.fao.org/), and expert advice may be used to estimate areas that are drained/managed. For Forest Land, national data will be available at soil survey organisations and from wetland surveys, e.g., for international conventions. In case no stratification by soil fertility is possible, countries may rely on expert judgment.

For this inventory cycle no information and data regarding cultivation of organic soils were available.

5.5.2.1.2.6 AD and calculation for N Input from *Urine and dung from grazing animals (F_{PRP})*

Activity data, parameter and emission calculation for *N Input from Urine and dung from grazing animals (FPRP)*

The term F_{PRP} refers to the annual amount of N deposited on pasture, range and paddock soils by grazing animals. It is important to note that the N from managed animal manure applied to soils is included in the F_{AM} term of F_{ON}. The annual amount of N deposited on pasture, range and paddock F_{PRP} is estimated using Equation 11.5 from 2006 IPCC GL, Volume 4, Chapter 11.

Equation 11.5: N in urine and dung deposited by grazing animals on pasture, range and paddock (PRP) (TIER 1) (2006 IPCC GL, Vol. 4, Chap. 11.2.1.3)

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

Where:

- F_{PRP} = annual amount of urine and dung N deposited on pasture, range, paddock (PRP) and by grazing animals (kg N yr^{-1})
- $N_{(T)}$ = number of head of livestock species/category T
- $Nex_{(T)}$ = annual average N excretion per head of species/category T (kg N animal-1 $^{yr-1}$)
- $MS_{(T,PRP)}$ = fraction of total annual N excretion for each livestock species/category T that is deposited on pasture, range and paddock (PRP).

Data used for estimation the annual amount of urine and dung N deposited on pasture, range, paddock (PRP) and by grazing animals are already used in other categories of IPCC Sector *Agriculture* and presented above.

$N_{(T)}$ - Number of head of livestock species/category T

The activity data are the same as used in category 3.A Enteric Fermentation and 3.B Manure Management and are presented in Table 230, Table 231, Table 232.

$Nex_{(T)}$ - Annual average N excretion per animal of species/category T

The annual average N excretion per animal of species/category T ($Nex_{(T)}$) is calculated with Equation 10.30 of 2006 IPCC GL[178], presented in Table 245 and exemplarily calculated in Table 246 (direct N_2O emissions) in Chapter 5.3.2.

$MS_{(T,PRP)}$ - fraction of total annual N excretion for each livestock species/category T that is deposited on pasture, range and paddock (PRP)

The fraction of total annual N excretion for each livestock species/category T that is deposited on pasture, range and paddock (PRP) is defined in Table 239 and is presented in Table 240.

With the Equation 11.1.a (see also above in 5.5.2.1.1 Choice of methods) and the Equation for conversion N_2O-N tot N_2O the N_2O emissions from N inputs to managed soils

Annual direct N_2O–N emissions from N inputs to managed soils (2006 IPCC GL, Vol. 4, Chap. 11)

$$N_2O - N_{N\ inputs} = \left[\left[\left(F_{PRP}\right) \times EF_1\right] + \left[\left(F_{PRP}\right)_{FR} \times EF_{1FR}\right]\right] \qquad \textbf{(11.1.a)}$$

[178] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10: Emissions from Livestock and Manure Management, sub-chapter 10.5.2 Choice of emission factors, p. 10.57.

$$N_2O\ emissions_{direct} = N_2O - N \times \frac{44}{28}$$

Table 273 **Nitrous oxide emissions from N Input from N in urine and dung deposited by grazing animals on pasture, range and paddock (PRP)**

Parameter	N Excretion on Pasture Range & Paddock	Emission Factor – N_2O-N	N_2O-N emissions	N_2O emissions	Method	EF used
Abbreviation	F_{PRP}	EF_3 - N_2O-N	N_2O-N	N_2O		
Unit	t N	kg N_2O-N/kg N	Gg	Gg		
1990	73,269	0.01	0.77	1.21	T1	D
1991	62,183	0.01	0.76	1.19	T1	D
1992	53,518	0.01	0.76	1.19	T1	D
1993	50,970	0.01	0.76	1.19	T1	D
1994	17,839	0.01	0.77	1.22	T1	D
1995	12,742	0.01	0.83	1.30	T1	D
1996	6,371	0.01	0.98	1.54	T1	D
1997	6,371	0.01	1.07	1.68	T1	D
1998	6,371	0.01	1.13	1.77	T1	D
1999	6,371	0.01	1.27	1.99	T1	D
2000	6,371	0.01	1.07	1.68	T1	D
2001	23,446	0.01	0.89	1.40	T1	D
2002	23,446	0.01	1.29	2.03	T1	D
2003	20,320	0.01	1.33	2.08	T1	D
2004	23,383	0.01	1.25	1.97	T1	D
2005	25,096	0.01	1.29	2.03	T1	D
2006	26,651	0.01	1.36	2.14	T1	D
2007	28,205	0.01	1.45	2.28	T1	D
2008	23,289	0.01	1.55	2.43	T1	D
2009	35,236	0.01	1.57	2.47	T1	D
2010	33,159	0.01	1.84	2.90	T1	D
2011	49,936	0.01	1.82	2.86	T1	D
2012	82,116	0.01	1.73	2.72	T1	D
2013	114,296	0.01	1.73	2.71	T1	D
2014	92,616	0.01	1.76	2.77	T1	D
2015	92,616	0.01	1.74	2.73	T1	D
2016	92,616	0.01	1.73	2.72	T1	D
2017	92,616	0.01	1.73	2.72	T1	D

5.5.2.1.3 Uncertainties and time-series consistency for IPCC sub-category 3.D.a Direct N_2O emissions

The uncertainties for activity data and emission factors used for IPCC category 3.D Agricultural soils are presented in the following table.

Table 274 Uncertainty for IPCC sub-category 3.D.a Direct N_2O emissions

Uncertainty	CH_4	N_2O	N_2O	Reference
				2006 IPCC GL, Vol. 4, Chap. 10
Activity data	NA	20%	NA	Chapter 11.2.1.4
Emission factor (direct emission)		250%		Chapter 10.4.4
Combined Uncertainty		254%		

Mazar-e-Sharif, Afghanistan ©Mohammad Monib Noori

5.5.3 Indirect N_2O emissions from managed soils (IPCC category 3.D.b)

3.D.b	**Indirect N_2O Emissions from managed soils**	
3.D.b.1	Atmospheric deposition	Volatilized N from agricultural inputs of N
3.D.b.2	Nitrogen leaching and run-off	N from fertilizers and other agricultural inputs that is lost through leaching and run-off

In addition to the direct emissions of N_2O from managed soils, emissions of N_2O also take place through two indirect pathways.

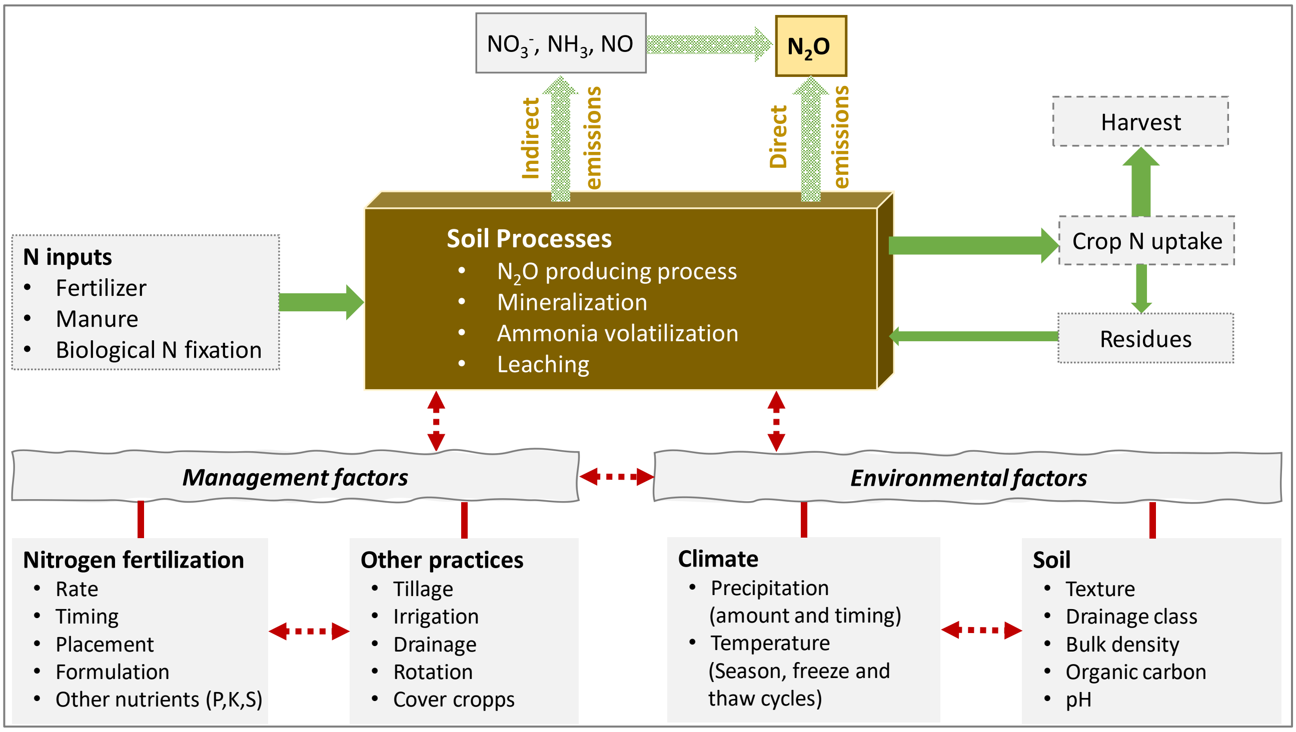


Figure 170 Factors influencing direct and indirect emissions of N_2O from agricultural soils

Source: WATTIAUX, M. A.; PAS, UDDIN, M. E. ; LETELIER, P., JACKSON, R. D. & LARSON, R. A. (2019): Emission and mitigation of greenhouse gases from dairy farms: The cow, the manure, and the field. In: Applied Animal Science 35:238–254. Sustainability and Integrated Systems. https://doi.org/10.15232/aas.2018-01803
Available on 29.04.2019 at: https://www.researchgate.net/publication/331916870_Invited_Review_Emission_and_mitigation_of_greenhouse_gases_from_dairy_farms_The_cow_the_manure_and_the_field

The first pathways is the volatilisation of N as NH_3 and oxides of N (NO_x), and the deposition of these gases and their products NH_4^+ and NO_3^- onto soils and the surface of lakes and other waters (see also Figure 170). As described in the 2006 IPCC GL, Vol. 4, Chapter 11.2.2 the sources of N as NH_3 and NO_x are not confined to agricultural fertilisers and manures, but also include fossil fuel combustion, biomass burning, and processes in the chemical industry. Thus, these processes cause N_2O emissions in an exactly analogous way to those resulting from deposition of agriculturally derived NH_3 and NO_x, following the application of synthetic and organic N fertilizers and /or urine and dung deposition from grazing animals (see also Figure 160).

The second pathway is the leaching and runoff from land of N from synthetic and organic fertilizer additions, crop residues, mineralization of N associated with loss of soil C in mineral and drained/managed organic soils through land-use change or management practices, and urine and dung deposition from grazing animals. As described in the 2006 IPCC GL, Vol. 4, Chapter 11.2.2 some of the inorganic N in or on the soil, mainly in the

NO_3^- form, may bypass biological retention mechanisms in the soil/vegetation system by transport in overland water flow (runoff) and/or flow through soil macropores or pipe drains. Where NO_3^- is present in the soil in excess of biological demand, e.g., under cattle urine patches, the excess leaches through the soil profile. The nitrification and denitrification processes described at the beginning of this chapter transform some of the NH_4^+ and NO_3^- to N_2O. This may take place in the groundwater below the land to which the N was applied, or in riparian zones receiving drain or runoff water, or in the ditches, streams, rivers and estuaries (and their sediments) into which the land drainage water eventually flows.

Thus, agricultural nitrogen (N) sources of indirect N_2O emissions from managed soils arise from

- synthetic N fertilizers (F_{SN});
- organic N applied as fertilizer (e.g., applied animal manure, compost, sewage sludge, rendering waste and other organic amendments) (F_{ON});
- urine and dung N deposited on pasture, range and paddock by grazing animals (F_{PRP});
- N in crop residues (above- and below-ground), including N-fixing crops and forage/pasture renewal returned to soils (F_{CR}); and
- N mineralization associated with loss of soil organic matter resulting from change of land use or management on mineral soils (F_{SOM}).

5.5.3.1 Methodological issues

5.5.3.1.1 Choice of methods

TIER 1 approach - $N_2O_{(ATD)}$ Volatilization

For estimating the N_2O emissions from atmospheric deposition of N volatilized from managed the 2006 IPCC Guidelines Tier 1 approach[179] has been applied.

Equation 11.9: N_2O from atmospheric deposition of N volatilized from managed soils (TIER 1)

(2006 IPCC GL, Vol. 4, Chap. 11)

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

Where:

$N_2O_{(ATD)}$–N = annual amount of N_2O–N produced from atmospheric deposition of N volatilized from managed soils (kg N_2O–N yr^{-1})

F_{SN} = annual amount of synthetic fertiliser N applied to soils (kg N yr^{-1})

$Frac_{GASF}$ = fraction of synthetic fertiliser N that volatilises as NH3 and NOx (kg N volatilized (kg of N applied)$^{-1}$)

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils (kg N yr^{-1})

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock (kg N yr-1)

$Frac_{GASM}$ = fraction of applied organic N fertiliser materials (FON) and of urine and dung N deposited by grazing animals (FPRP) that volatilises as NH3 and NOx (kg N volatilized (kg of N applied or deposited)$^{-1}$) (Table 11.3)

EF_4 = emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces ([kg N–N_2O (kg NH3–N + NOx–N volatilized)$^{-1}$])

[179] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chap. 11, sub-chap. 11.2.2.1 Choice of method

Conversion of $N_2O_{(ATD)}$-N emissions to N_2O emissions for reporting purposes is performed by using the following equation:

Equation 11.10: Indirect N_2O emissions due to volatilization of N from manure management

$$N_2O_{(ATD)} = N_2O_{(ATD)} - N \times \frac{44}{28}$$

Where:

$N_2O_{(ATD)}$ = indirect N_2O emissions due to volatilization of N from Manure Management (kg N_2O)

$N_2O_{(ATD)}$–N = annual amount of N_2O–N produced from atmospheric deposition of N volatilized from managed soils (kg N_2O–N yr^{-1})

44/28 = conversion of kg N_2O-N into kg N_2O.

TIER 1 approach - $N_2O_{(L)}$ Leaching/Runoff

For estimating the N_2O emissions from leaching and runoff in regions where leaching and runoff occurs the 2006 IPCC Guidelines Tier 1 approach[180] has been applied.

Equation 11.10: N_2O from N leaching/runoff from managed soils in regions where leaching/runoff occurs (TIER 1)

(2006 IPCC GL, Vol. 4, Chap. 11)

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

Where:

$N_2O_{(L)}$–N = annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs (kg N_2O–N yr-1)

F_{SN} = annual amount of synthetic fertilizer N applied to soils in regions where leaching/runoff occurs (kg N yr-1)

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils in regions where leaching/runoff occurs (kg N yr-1)

F_{PRP} = annual amount of urine and dung N deposited by grazing animals in regions where leaching/runoff occurs (kg N yr-1)

from Equation 11.5, page 11.13, Chap. 11.2.1.3 Choice of activity data, Vol. 4 of 2006 IPCC GL

F_{CR} = amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually in regions where leaching/runoff occurs (kg N yr-1)

F_{SOM} = annual amount of N mineralized in mineral soils associated with loss of soil C from soil organic matter as a result of changes to land use or management in regions where leaching/runoff occurs (kg N yr-1)

from Equation 11.8, page 11.16, Chap. 11.2.1.3 Choice of activity data, Vol. 4 of 2006 IPCC GL

$Frac_{LEACH-(H)}$ = fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff (kg N (kg of N additions)-1)

from Table 11.3, page 11.23, Chap. 11.2.2.3 Choice of activity data, Vol. 4 of 2006 IPCC GL and presented in Table 275

EF_5 = emission factor for N_2O emissions from N leaching and runoff (kg N_2O–N (kg N leached & runoff)$^{-1}$)

from Table 11.3, page 11.23, Chap. 11.2.2.3 Choice of activity data, Vol. 4 of 2006 IPCC GL and presented in Table 275 in

[180] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chap. 11, sub-chap. 11.2.2.1 Choice of method

Conversion of $N_2O_{(L)}$-N emissions to N_2O emissions for reporting purposes is performed by using the following equation:

Equation 11.10: Indirect N_2O emissions due to volatilization of N from manure management

$$N_2O_{(AL)} = N_2O_{(L)} - N \times \frac{44}{28}$$

Where:

$N_2O_{(L)}$ = indirect N_2O emissions due to leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs (kg N_2O)

$N_2O_{(L)}$–N = annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs (kg N_2O–N yr^{-1})

44/28 = conversion of kg N_2O-N into kg N_2O.

5.5.3.1.2 Choice of emission, volatilization and leaching factors

The method for estimating indirect N_2O emissions includes two emission factors:

- associated with volatilised and re-deposited N (EF_4),
- associated with N lost through leaching/runoff (EF_5).

The method also requires values for the fractions of N that are lost through volatilisation ($Frac_{GASF}$ and $Frac_{GASM}$) or leaching/runoff ($Frac_{LEACH-(H)}$).

As no country specific emission factors and values for the fractions of N that are lost were available, default emission factors and parameter were used.

Table 275 Default emission, volatilization and leaching factors for indirect soil N_2O emissions

Factor	Description	Unit	Default value
EF_4	N volatilisation and re-deposition	kg N_2O–N / (kg NH3–N + NOX–N volatilised)	0.010
EF_5	leaching/runoff	kg N_2O–N / (kg N leaching/runoff)	0.0075
$Frac_{GASF}$	Volatilization from synthetic fertilizer	(kg NH3–N + NOx–N) / (kg N applied)	0.10
$Frac_{GASM}$	Volatilization from all organic N fertilizers applied , and dung and urine deposited by grazing animals	(kg NH3–N + NOx–N) / (kg N applied or deposited)	0.20
$Frac_{LEACH-(H)}$	N losses by leaching/runoff for regions where ∑ (rain in rainy season) - ∑ (PE in same period) > soil water holding capacity, OR where irrigation (except drip irrigation) is employed	kg N / (kg N additions or deposition by grazing animals)	0.30
	N losses by leaching/runoff for dryland regions where precipitation is lower than evapotranspiration throughout most of the year and leaching is unlikely to occur		0

Source: 2006 IPCC GL, Vol. 4, Chap. 11, sub-chap. 11.2.2.3, Choice of activity data, Table 11.3, page 11.23

5.5.3.1.3 Choice of activity data

In order to estimate indirect N_2O emissions from the various N additions to managed soils, the parameters F_{SN}, F_{ON}, F_{PRP}, F_{CR}, F_{SOM} need to be estimated. These parameters are already described in Chapter 5.5.2.1.2 of this report described.

Applied synthetic fertiliser (F_{SN})

The term F_{SN} refers to the annual amount of synthetic fertiliser N applied to soils.
Relevant information is provided in Chapter 5.5.2.1.2.1 of this report.

Applied organic N fertilisers (F_{ON})

The term FON refers to the amount of organic N fertiliser materials intentionally applied to soils.
Relevant information is provided in Chapter 5.5.2.1.2.15.5.2.1.2.25.5.2.1.2.3 of this report.

Urine and dung from grazing animals (F_{PRP})

The term F_{PRP} refers to the amount of N deposited on soil by animals grazing on pasture, range and paddock.
Relevant information is provided in Chapter 5.5.2.1.2.6 of this report.

Crop residue N, including N from N-fixing crops and forage/pasture renewal, returned to soils (F_{CR})

The term FCR refers to the amount of N in crop residues (above- and below-ground), including N-fixing crops, returned to soils annually. It also includes the N from N-fixing and non-N-fixing forages mineralised during forage/pasture renewal.
Relevant information is provided in Chapter 5.5.2.1.2.1 of this report.

Mineralised N resulting from loss of soil organic C stocks in mineral soils (F_{SOM})

The term F_{SOM} refers to the amount of N mineralised from the loss of soil organic C in mineral soils through land-use change or management practices.
Relevant information is provided in Chapter 5.5.2.1.2.4 of this report.

5.5.4 Uncertainties and time-series consistency for IPCC category 3.D Agricultural soils

The uncertainties for activity data and emission factors used for IPCC category 3.D Agricultural soils are presented in the following table.

Table 276 Uncertainty for IPCC sub-category 3.D Agricultural soils.

Uncertainty		N_2O	Reference
			2006 IPCC GL, Vol. 4, Chap. 11
Activity data			
$Frac_{loss}$	amount of managed manure nitrogen for livestock category that is lost in the manure management system	20%	Table 10.32 p 10.67
F_{sn}	activity data on synthetic fertilizer	20%	Expert judgment
F_{cr}	activity data crop residues	20%	Expert judgment
EF_1	N_2O emission factor for soils	250%	Table 11.1, page 11.11
EF_{PRP}	emission factor N deposited by grazing animals on pasture, range and paddock	200%	Table 11.1 page 11.11
EF_4	N volatilization and re-deposition	50%	Table 11.1 page 11.11
Combined Uncertainty		326%	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

5.5.5 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of livestock data (statistical yearbook and FAOstat- Live Animals),
  - consistent use of data on area and yield of crops (statistical yearbook and FAOstat- crops),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked of different sources: national statistic (NSIA, CountryStat) and international statistics (FAO)

All national and international data are compared and discussed with national experts from Ministry of Agriculture Irrigation and Livestock (MAIL), National Statistics and Information Authority (NSIA), National Protection Agency (NEPA), Independent Directorate of Local Governance (IDLG), Municipality of Kabul, and University of Kabul and Kabul Polytechnic University.

See also Chapter 5.2.4

⇒ discussion of manure management systems with national experts from Ministry of Agriculture Irrigation and Livestock (MAIL), National Statistics and Information Authority (NSIA), National Protection Agency (NEPA), Independent Directorate of Local Governance (IDLG), Municipality of Kabul, and University of Kabul and Kabul Polytechnic University.

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

5.5.6 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category 3.D Agricultural soils.

Table 277 Recalculations done since SNC in IPCC sub-category 3.D Agricultural soils

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
3.D	application of 2006 IPCC Guidelines	method	Comparability
3.D.a	use of N_2O default emission factor (direct emission) of 2006 IPCC Guidelines	EF	Comparability
3.D.b	use of N_2O default emission factor (indirect emission) of 2006 IPCC Guidelines	EF	Comparability

5.5.7 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 278 Planned improvements for IPCC sub-category 3.D Agricultural soils

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.D	F_{SN} - Annual amount of applied synthetic fertilizer consumption applied to soils • amount and type (fertilizers by product and/or nutrient) of annual amount of applied synthetic fertilizer • split of fertilizer used in for crops and for flooded rice fields	AD	Accuracy Consistency Transparency	high
3.D	F_{ON} - annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils • amount of animal manure and N content, • amount of compost and N content, • amount of sewage sludge and N content (cross-check with Waste Sector to ensure there is no double counting), • annual amount of other organic amendments used as fertiliser (e.g., rendering waste, guano, brewery waste, etc.) and N content • split of split of fertilizer used in for crops and for flooded rice fields used in for crops and for flooded rice fields	AD	Accuracy Consistency Transparency	high
3.D	(1) $Area_{(T)}$ - Total annual area harvested of crops (types) (2) $Yield_{\_Fresh(T)}$ - Harvested fresh yield for crop T (3) Area burnt $_{(T)}$ - annual area of crop T burned (4) Dry matter (d.m.) fraction (DRY) • grains: e.g. wheat (split in winter and summer harvest), barley, oats, rice, rye, millet, maize (corn), sorghum, spelt, teff, (wild) rice, etc. • beans & pulses: e.g. beans, lentils, peas, etc. • tubers: e.g. (sweet) potato, yam, cassava, sweet lupins, etc. • root crops: beets-roots, sugar beet, pigweed, sunflower, mustard, carrots, etc. • N-fixing forages • Non-N-fixing forages • Perennial grasses • Grass-clover mixtures	AD	Accuracy Consistency Transparency	high
3.D	SOC_0 - soil organic carbon stock in the last year of an inventory time period (tonnes C) $SOC_{(0-T)}$ - soil organic carbon stock at the beginning of the inventory time period (tonnes C) *See Planned Improvements for LULUCF*	AD	Accuracy Transparency Consistency Comparability Completeness	medium
3.D	(1) number of head of livestock species/category T fraction of total annual N excretion for each livestock (2) species/category T that is deposited on pasture, range and paddock (PRP) (3) annual average N excretion per head of species/category T *see Planned Improvements for 3.B. Enteric Fermentation and 3.A. Manure management*	AD	Accuracy Consistency	High

5.6 Prescribed burning of savannas (IPCC category 3.E)

GHG emission from IPCC category 3.E Prescribed burning of savannas were not estimated due to lack of information including data about prescribed fires and wildfires.

However, according to national experts prescribed fires and wildfires occurs occasionally in Afghanistan. In FAO stat emissions from this category were estimated. The presented information includes not all activity data therefore the estimation of GHG emission were not completely reproducible.

GHG emissions from this sector comprise emissions from the following categories:

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.E	**Prescribed burning of savannas**	NA	-	NE	-	NE	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

5.6.1 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 279 Planned improvements for IPCC sub-category 3.F Field burning of agricultural residues

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.E	Analysis of relevant activity data regarding prescribed fires and wildfires	AD	Accuracy Consistency Comparability Transparency	high

5.7 Field burning of agricultural residues (IPCC category 3.F)

Crop residues are sometimes burned, for convenience and as a means of disease control through residue removals. As described in the *2006 IPCC Guidelines Volume 4, Chapter 5.2.4,* CH_4 and N_2O emissions from *Cropland* are usually associated with burning of agriculture residues, which vary by crop and management system. Field burning of agricultural residues emits CH_4 and N_2O. CO_2 emissions from biomass burning do not have to be reported, since the carbon released during the combustion process is assumed to be reabsorbed by the vegetation during the next growing season.

This chapter includes information on, and description of methodologies used for estimating GHG emissions as well as references to activity data and emission factors reported under IPCC category *Field burning of agricultural residues* for the period 1990 to 2017.

GHG emissions from this sector comprise emissions from the following categories:

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.F	**Field burning of agricultural residues**	NA	-	✓	-	✓	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

5.7.1 Source category description

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.F	**Field burning of agricultural residues**	NA	-	✓	-	✓	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

In 2017, this source category was responsible for

- 0.1% of agricultural methane emissions and for less than 0.1% of the total methane emissions estimated for Afghanistan.
- 0.1% of agricultural nitrous oxide (N_2O) emissions and for less than 0.1% of the total nitrous oxide (N_2O) emissions estimated for Afghanistan.

It represented about 0.1% of the total GHG emissions from the agriculture sector and less than 0.1% of the total GHG emissions in CO_2eq (excluding LULUCF).

In the period 1990 – 2017 the CH_4 emissions increased by 129% and the N_2O emissions increased by 169%. In the period 2005 – 2017 the CH_4 emissions increased by 12% and the N_2O emissions increased by 45% mainly due to increased cultivation of crops.

An overview of the methane emissions resulting IPCC category 3.F *Field burning of agricultural residues* is provided in the following figure and table.

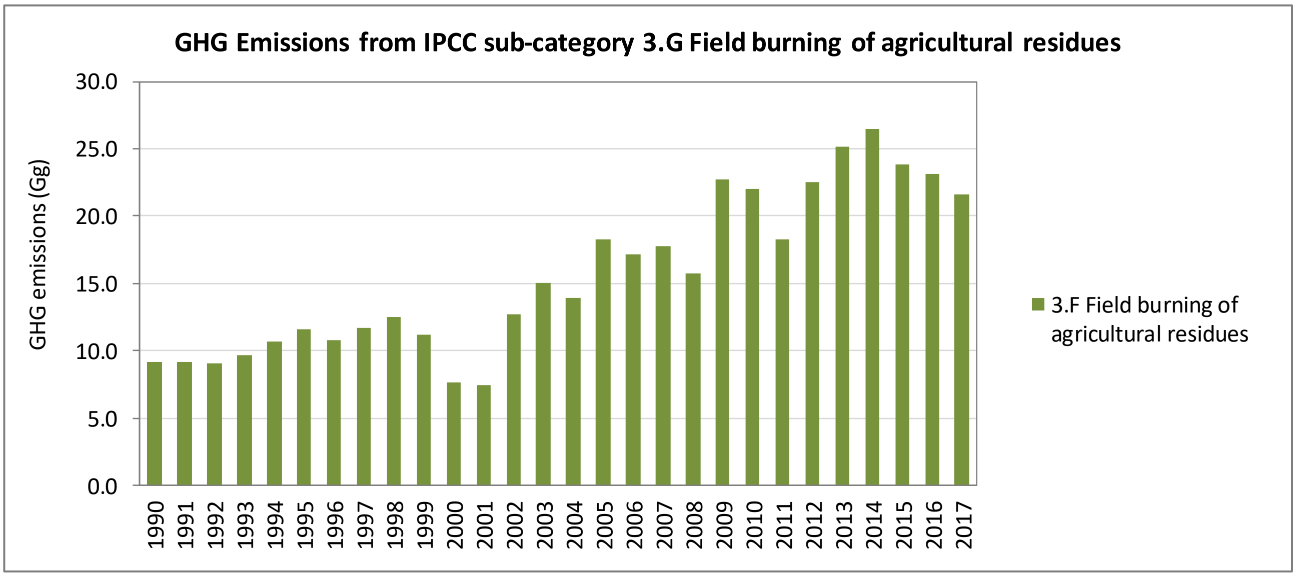


Figure 171 CH_4 Emissions from IPCC sub-category 3.F Field burning of agricultural residues

Table 280 GHG Emissions from IPCC category 3.F Field burning of agricultural residues

GHG emissions	TOTAL GHG	CO_2	CH_4	N_2O	CH_4	N_2O
	Gg CO2 equivalent	Gg	Gg CO2 equivalent	Gg CO2 equivalent	Gg	Gg
1990	8.87	NA	7.11	1.75	0.28	0.01
1991	9.15	NA	7.33	1.82	0.29	0.01
1992	9.10	NA	7.18	1.91	0.29	0.01
1993	9.65	NA	7.81	1.83	0.31	0.01
1994	10.70	NA	8.56	2.13	0.34	0.01
1995	11.58	NA	9.16	2.42	0.37	0.01
1996	10.77	NA	8.74	2.02	0.35	0.01
1997	11.72	NA	9.66	2.06	0.39	0.01
1998	12.48	NA	10.24	2.23	0.41	0.01
1999	11.14	NA	9.06	2.08	0.36	0.01
2000	7.67	NA	6.03	1.64	0.24	0.01
2001	7.45	NA	6.00	1.45	0.24	0.00
2002	12.67	NA	10.28	2.39	0.41	0.01
2003	15.03	NA	12.27	2.76	0.49	0.01
2004	13.91	NA	10.87	3.04	0.43	0.01
2005	18.27	NA	14.96	3.31	0.60	0.01
2006	17.15	NA	13.65	3.50	0.55	0.01
2007	17.77	NA	14.88	2.89	0.60	0.01
2008	15.78	NA	12.28	3.50	0.49	0.01
2009	22.73	NA	18.47	4.26	0.74	0.01
2010	22.06	NA	17.65	4.41	0.71	0.01
2011	18.30	NA	14.40	3.90	0.58	0.01
2012	22.48	NA	18.26	4.22	0.73	0.01
2013	25.19	NA	20.05	5.15	0.80	0.02

GHG emissions	TOTAL GHG	CO_2	CH_4	N_2O	CH_4	N_2O
	Gg CO2 equivalent	Gg	Gg CO2 equivalent	Gg CO2 equivalent	Gg	Gg
2014	26.43	NA	20.98	5.45	0.84	0.02
2015	23.87	NA	18.75	5.12	0.75	0.02
2016	23.16	NA	18.14	5.01	0.73	0.02
2017	21.60	NA	16.82	4.78	0.67	0.02
Trend						
1990 - 2017	*136.7%*	*NA*	*128.9%*	*168.9%*	*128.9%*	*168.9%*
2005 - 2017	*18.2%*	*NA*	*12.4%*	*44.7%*	*12.4%*	*44.7%*
2012 - 2017	*-3.9%*	*NA*	*-7.9%*	*13.4%*	*-7.9%*	*13.4%*
2016 - 2017	*-6.7%*	*NA*	*-7.3%*	*-4.6%*	*-7.3%*	*-4.6%*

5.7.2 Methodological issues

5.7.2.1 Choice of methods

TIER 1 approach

For estimating the CH_4 and N_2O emissions from *Field burning of agricultural residues* the 2006 IPCC Guidelines Tier 1 approach[181] has been applied.

As described in chapter 5.7.2.3 the estimation of the emission factor is following the *Reference Manual* of the *Revised 1996 IPCC Guidelines* (Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues).

Equation 5.1: CH_4 and N_2O emissions from Field burning of agricultural residues

(2006 IPCC Guidelines, Vol. 4, Chap 5.2.4.1 and Chap. 2.4)

$$\boldsymbol{Emissions_{GHG}} = \sum \boldsymbol{AD_{burnt}} \times \frac{\boldsymbol{EF_{GHG}}}{\boldsymbol{1000}} \times \boldsymbol{Frac_{oxidized}}$$

with

$$\boldsymbol{AD_{burnt}} = \sum_{\boldsymbol{T}} (\boldsymbol{production_T} \times \boldsymbol{DRY} \times \mathrm{Res}_{\boldsymbol{O}} \times \boldsymbol{Frac_{burnt}})$$

with

$$\boldsymbol{EF_{CH4}} = \boldsymbol{C\ Fraction_{residue\ T}} \times \boldsymbol{emission\ ratio} \times \frac{\boldsymbol{16}}{\boldsymbol{12}}$$

$$\boldsymbol{EF_{N2O}} = \boldsymbol{C\ Fraction_{residue\ T}} \times (\boldsymbol{N/C\ ratio}) \times \boldsymbol{emission\ ratio} \times \frac{\boldsymbol{44}}{\boldsymbol{28}}$$

[181] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 5 Cropland, sub-chap 5.2.4.1 Choice of method and chapter 2.4 Non-CO_2 emissions

Where:

$Emissions_{GHG, fuel}$	= emissions of a given GHG by type of crop (Gg GHG)
GHG	= CH_4, N_2O
AD_{Burnt}	= amount of biomass (crop residue) burnt from crop T (Mg dry matter)
EF_{GHG}	= emission factor of a given GHG by type of crop based on dry matter burnet (g kg^{-1} dry matter burnt)
$Frac_{oxidized}$	= fraction oxidized
$Production_T$	= production of crop T (Mg)
DRY	= dry matter fraction of Harvested product
Res_O	= Residue/Crop Ratio (unitless)
$Frac_{burnt}$	= fraction of crop residue that is subject to field burning for crop T
C fraction of residues	= C fraction of residues - Carbon content of the residue (tonnes of carbon / tonnes of dry matter)
Emission ratios	= Emission ratios for agricultural residue burning calculations
N/C ratio	= N-C ratio of the fuel (crop residues) by weight to yield the total amount of nitrogen (N) released

In Table 263 is provided an exemplary calculation of CH_4 and N_2O emissions from *Field burning of agricultural residues* (TIER 1) from wheat.

5.7.2.2 Choice of activity data

The agricultural data used and presented in this inventory are taken from national and international sources:

- Afghanistan Statistical yearbook[182]
- FAO agricultural data base[183]

In the following Figures and Table 283 are provided the data on cultivated and harvested crops presented.

The percentage of the agricultural crop residues burnt on-site, which is the mass of fuel available for burning, should be estimated taking into account the fractions removed before burning due to animal consumption, decay in the field, and use in other sectors (e.g., biofuel, domestic livestock feed, building materials, etc.). This is important to eliminate the possibility of double counting

For estimating the biomass burnt on field the parameter (1) Residue/Crop Ratio, (2) Dry Matter Fraction and (3) Fraction of Crop Residue Burnt in Fields were used and presented in the following Table.

Table 281 Fraction of Crop Residue Burned in Fields, Dry Matter Fraction and Residue/Crop Ratio

Fuel	Residue/Crop Ratio	Dry Matter Fraction (DRY)	Fraction of Crop Residue Burnt in Fields
Wheat	1.3	0.89	0.03
Barley	1.2	0.89	0.03
Maize	1.0	0.87	0.03
Rice	1.4	0.89	0.03

[182] Available (03. March 2019) on https://www.nsia.gov.af/library
[183] Available (03. March 2019) on http://www.fao.org/faostat/en/#data/QC

Fuel	Residue/Crop Ratio	Dry Matter Fraction (DRY)	Fraction of Crop Residue Burnt in Fields
Peas	1.5	0.87 [b]	0.03
Potatoes	0.4 *	0.22	0.03
Sugar beet	2.2	0.72 [b]	0.03
Cotton	1.3 **	0.85	0.03
Feetbeet	0.3 *	0.86 *	0.03
Peanuts	1.0 *	0.86 [b]	0.03
Sunflower	1.3 *	0.85 [c]	0.03
Source	Table 4.16, IPCC GPG 2000, Chap. 4_Agriculture, page 4.58.[184] * as of beans & soybeans ** as of wheat	Table 11.2, 2006 IPCC GL, Vol. 4, Chap. 11, page 11.17 [b] Table 4.16, IPCC GPG 2000, Chap. 4, page 4.58. [c] Table 11.1A, 2019 Refinement to the 2006 IPCC GL, Vol. 4. Chap. 11, page 11.17.[185]	Based on expert judgment and Table 4.19, 1996 IPCC GL, Reference Manual, Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues, page 4.83.[186]

Traditional Agriculture System, Bamyan, Afghanistan ©Mohammad Ayub Alavi

[184] https://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf
[185] https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch11_Soils_N$_2$O_CO$_2$.pdf
[186] https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/CH$_4$ref6.pdf

Table 282 Exemplary calculation of N_2O and CH_4 emissions from IPCC category 3.F Field burning of agricultural residues (TIER 1) – wheat

Parameter	Parameter description	Unit	Formula	Parameter Source	2017
$Crop_O$	**Crop Production - Wheat**	**t**	-	**1996-1997, 2000-2017: NSIA Statistical YB (all years), Table 8-3 1990-2017: FAO STAT Crops**	**4,280,776**
Res_O	**Residue/Crop Ratio**	ratio	-	Table 4.16, IPCC GPG 2000, Chap. 4_Agriculture, page 4.58	1.3
$FRAC_{DM}$	**Dry Matter Fraction**	ratio	-	Table 11.2, 2006 IPCC GL, Vol. 4, Chap. 11, page 11.17 Table 4.16, IPCC GPG 2000, Chap. 4, page 4.58. Table 11.1A, 2019 Refinement, Vol. 4. Chap. 11, page 11.17.	0.84
$FRAC_{BURN}$	**Fraction of Crop Residue Burned in Fields**	kg N/kg crop-N	-	Table 4.19, 1996 IPCC GL, Reference Manual, Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues, page 4.83.	0.03
$FRAC_{OX}$	**Fraction Oxidized**	ratio		1996 IPCC GL, Reference Manual, Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues, page 4.83.	0.9
BIO_{BURN}	**Total Biomass Burned**	**Gg dm**	**$(Crop_O /1000) \times Res_O \times FRAC_{DM} \times FRAC_{BURN} \times FRAC_{OX}$**	**2006 IPCC Guidelines, Vol. 4, Chap 5.2.4.1 and Chap. 2.4)**	**126.2144**
C $FRAC_R$	**C Fraction of Residue**	ratio	-	Table 4.16 - GPG_2000	0.4853
N $FRAC_R$	**N Fraction of Residue**	Ratio	-	Table 4.16 - GPG_2000	0.0028
N-C BIO_R	**N-C ratio in Biomass Residue**	ratio	N $FRAC_R$ / N $FRAC_C$		0.006
E_{R-CH4}	**Emission ratio CH_4**	ratio		Table 4-17, 1996 IPCC GL, Ref Manual, Chap, 4.4.3, page 4.83.	0.005
E_{R-N2O}	**Emission ratio N_2O**	ratio		Table 4-17, 1996 IPCC GL, Ref Manual, Chap, 4.4.3, page 4.83.	0.007
C_{f-CH4}	**Conversion factor CH_4**	-	16 / 12	stoichiometry	1.333
C_{f-N2O}	**Conversion factor N_2O**	-	44 / 28	stoichiometry	1.571
EF - CH_4	**Emission Factor - CH_4**	**kg/t-dm**	**C $FRAC_R \times E_{R-CH4} \times C_{f-CH4}$**	**Reference Manual, Revised 1996 IPCC GL (Vol. 3), Chap, 4.4.3**	**0.003**
CH_4	**CH_4 emissions**	**Gg**	$BIO_{BURN} * EF_{CH4}$	**2006 IPCC Guidelines, Vol. 4, Chap 5.2.4.1 and Chap. 2.4)**	**0.41**
CH_4	Method	-	-	-	T1
CH_4	EF used	-	-	-	D
EF - N_2O	**Emission Factor - N_2O**	**kg/t-dm**	**N $FRAC_R$ x N-C $BIO_R \times E_{R-N2O} \times C_{f-N2O}$**	**Reference Manual, Revised 1996 IPCC GL (Vol. 3), Chap, 4.4.3**	**0.00003**
N_2O	**N_2O emissions**	**Gg**	$BIO_{BURN} * EF_{N2O}$	**2006 IPCC Guidelines, Vol. 4, Chap 5.2.4.1 and Chap. 2.4)**	**0.004**
N_2O	Method	-	-	-	T1
N_2O	EF used	-	-	-	D

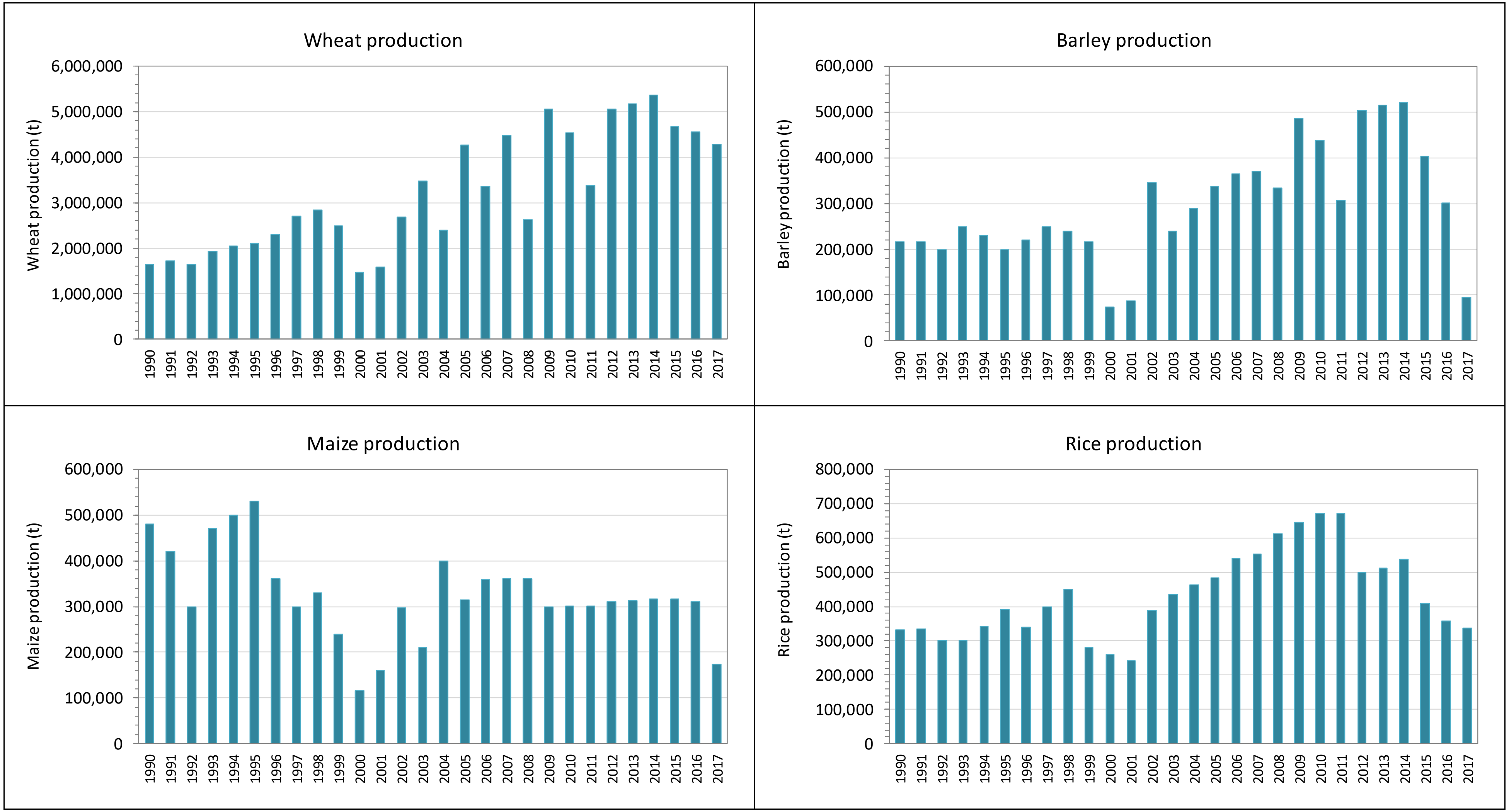


Figure 172 Wheat, barley, maize and rice: harvested of crops

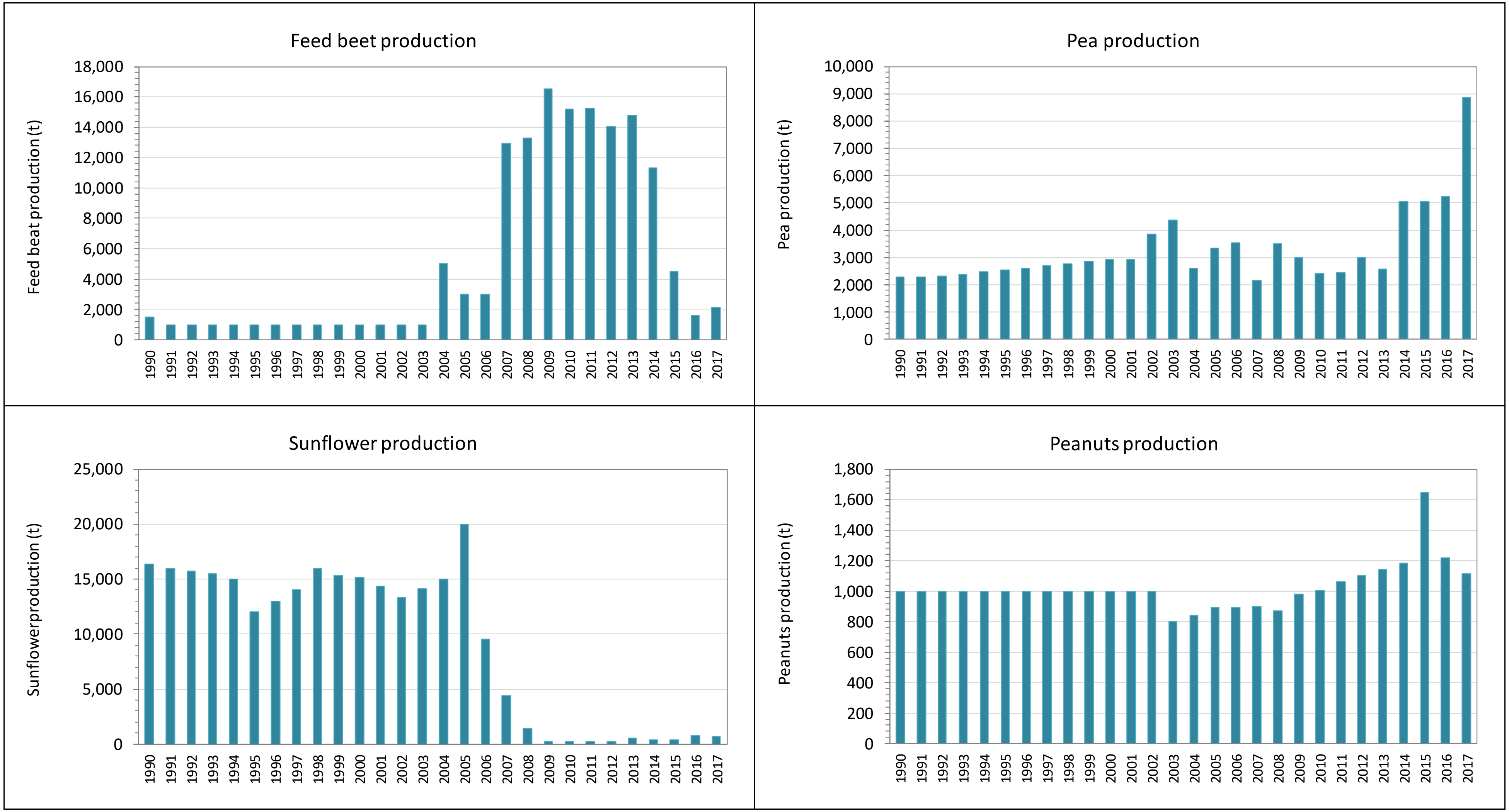


Figure 173 **Feed beets, peas, peanuts and sunflower: harvested of crops**

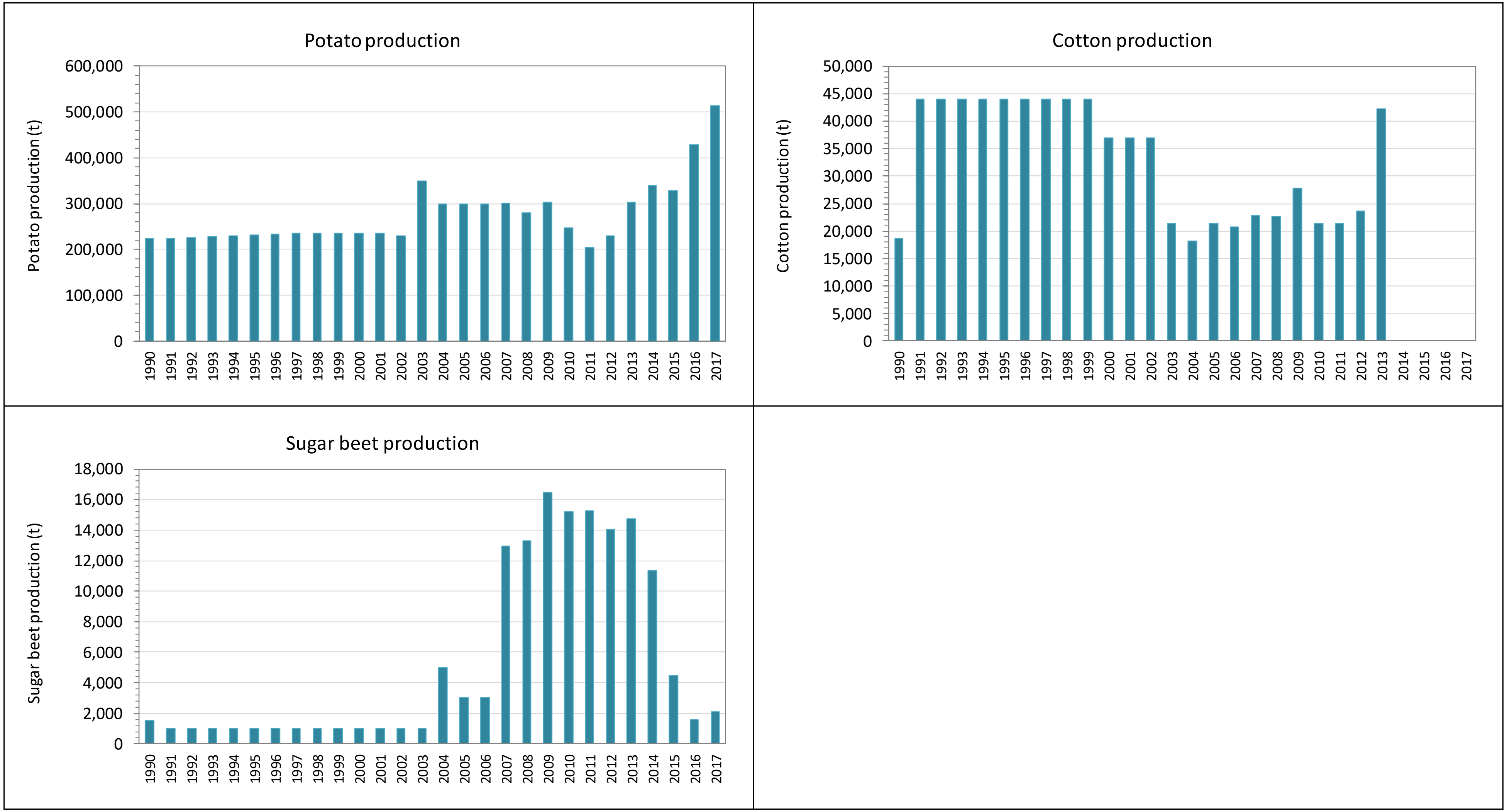


Figure 174 **Potatoes, sugar beet, and cotton: harvested of crops**

Table 283 Total annual amount of harvested crops: cereals, pules, potatoes and other crops

	Wheat	Barley	Maize	Rice	Peas	Potatoes	Sugar beet	Cotton	Feet beet	Peanuts	Sunflower
Unit	**t**	**t**	**t**	**t**	**t**	**t**	**t**	**t**	**t**	**t**	**t**
1990	1,650,000	216,000	480,000	333,000	2,296	224,000	1,500	18,700	1,500	1,000	16,400
1991	1,726,000	217,000	420,000	335,000	2,282	223,000	1,000	44,000	1,000	1,000	16,000
1992	1,650,000	200,000	300,000	300,000	2,331	225,000	1,000	44,000	1,000	1,000	15,715
1993	1,940,000	250,000	470,000	300,000	2,391	227,000	1,000	44,000	1,000	1,000	15,492
1994	2,050,000	230,000	500,000	342,000	2,469	229,000	1,000	44,000	1,000	1,000	15,000
1995	2,100,000	200,000	530,000	390,000	2,546	231,000	1,000	44,000	1,000	1,000	12,000
1996	2,300,000	220,000	360,000	340,000	2,623	233,000	1,000	44,000	1,000	1,000	13,000
1997	2,711,000	250,000	300,000	400,000	2,700	235,000	1,000	44,000	1,000	1,000	14,000
1998	2,834,000	240,000	330,000	450,000	2,778	235,000	1,000	44,000	1,000	1,000	16,000
1999	2,499,000	216,000	240,000	280,000	2,855	235,000	1,000	44,000	1,000	1,000	15,355
2000	1,469,000	74,000	115,000	260,000	2,932	235,000	1,000	37,000	1,000	1,000	15,145
2001	1,597,000	87,000	160,000	242,000	2,923	235,000	1,000	37,000	1,000	1,000	14,394
2002	2,686,000	345,000	298,000	388,000	3,857	230,000	1,000	37,000	1,000	1,000	13,334
2003	3,480,000	240,000	210,000	434,000	4,384	350,000	1,000	21,450	1,000	800	14,106
2004	2,390,000	290,000	400,000	463,000	2,617	300,000	5,000	18,200	5,000	840	15,000
2005	4,266,000	337,000	315,000	485,000	3,346	300,000	3,000	21,450	3,000	893	20,000
2006	3,363,000	364,000	359,000	540,000	3,540	300,000	3,000	20,800	3,000	893	9,500
2007	4,484,000	370,000	360,000	552,000	2,145	300,800	12,938	22,783	12,938	900	4,400
2008	2,623,000	333,000	360,000	612,000	3,500	280,000	13,316	22,750	13,316	873	1,400
2009	5,064,000	486,000	300,000	645,000	3,000	302,400	16,500	27,867	16,500	980	240
2010	4,532,000	437,000	301,000	672,000	2,419	246,000	15,200	21,450	15,200	1,003	245
2011	3,388,000	305,900	300,120	672,000	2,455	205,000	15,236	21,450	15,236	1,064	247
2012	5,050,000	504,000	310,000	500,000	3,000	230,000	14,064	23,595	14,064	1,102	250
2013	5,169,235	514,000	312,000	512,094	2,566	302,980	14,765	42,173	14,765	1,141	560

	Wheat	Barley	Maize	Rice	Peas	Potatoes	Sugar beet	Cotton	Feet beet	Peanuts	Sunflower
Unit	**t**	**t**	**t**	**t**	**t**	**t**	**t**	**t**	**t**	**t**	**t**
2014	5,370,259	521,000	316,000	537,000	5,056	340,257	11,330	-	11,330	1,182	393
2015	4,673,040	403,000	316,000	410,000	5,058	327,507	4,495	-	4,495	1,650	348
2016	4,555,110	301,856	311,646	356,565	5,226	427,917	1,582	-	1,582	1,219	770
2017	4,280,776	94,995	173,912	338,420	8,862	513,194	2,102	-	2,102	1,112	723
Trend											
1990 - 2017	*159%*	*-56%*	*-64%*	*2%*	*286%*	*129%*	*40%*	*NA*	*40%*	*11%*	*-96%*
2005 - 2017	*0%*	*-72%*	*-45%*	*-30%*	*165%*	*71%*	*-30%*	*NA*	*-30%*	*25%*	*-96%*
2016 - 2017	*-6%*	*-69%*	*-44%*	*-5%*	*70%*	*20%*	*33%*	*NA*	*33%*	*-9%*	*-6%*
Source	1996-1997, 2000-2017: NSIA Statistical Yearbooks (all years), Table 8-3 and Table 8-4 1990-2017: FAO STAT Crops[174]										

5.7.2.3 Choice of emission factors

The rationale for using the approach of the *Reference Manual* of the *Revised 1996 IPCC Guidelines* (Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues), and not the approach of the 2006 IPCC GL, Vol. 4. Chap. 5 and 2, is as follows:

(1) the 2006 IPCC GL equation was developed to be broadly applicable to all types of biomass burning, and, thus, is not specific to agricultural residues; and
(2) the 2006 IPCC GL default factors are provided only for four crops (corn, rice, sugarcane, and wheat), while this inventory analyzes emissions from much more crops.

Equation: Emission factor for CH_4 and Emission factor for N_2O from Field burning of agricultural residues

(*Reference Manual* of the *Revised 1996 IPCC Guidelines* (Vol. 3, Chap, 4.4.3))

$$\boldsymbol{EF_{CH4} = C\ Fraction_{residue\ T} \times emission\ ratio \times \frac{16}{12}}$$

$$\boldsymbol{EF_{N2O} = N\ Fraction_{residue\ T} \times (N/C\ ratio) \times emission\ ratio \times \frac{44}{28}}$$

Where:

EF_{GHG}	= emission factor of a given GHG by type of crop based on dry matter burnet (g kg^{-1} dry matter burnt)
GHG	= CH_4, N_2O
C fraction of residues	= C fraction of residues - Carbon content of the residue (tonnes of carbon / tonnes of dry matter)
N fraction of residues	= N fraction of residues - Nitrogen content of the residue (tonnes of nitrogen / tonnes of dry matter)
Emission ratios	= Emission ratios for agricultural residue burning calculations
N/C ratio	= N-C ratio of the fuel (crop residues) by weight to yield the total amount of nitrogen (N) released
16/12	= conversion factor to full molecular weights
44/28	= conversion factor to full molecular weights

As described in the *Reference Manual* of the *Revised 1996 IPCC Guidelines*, the emissions of CH_4, CO, N_2O, and NOx can be calculated based on emission ratios.

The amount of carbon released due to burning is multiplied by the emission ratios of CH_4 and CO relative to total carbon to yield emissions of CH_4 and CO (each expressed in units of C). The emissions of CH_4 and CO are multiplied by 16/12 and 28/12, respectively, to convert to full molecular weights.

To calculate emissions of N_2O and NOx, first the total carbon released is multiplied by the estimated N-C ratio of the fuel by weight to yield the total amount of nitrogen (N) released. The total N released is then multiplied by the ratios of emissions of N_2O and NOx relative to the N content of the fuel to yield emissions of N_2O and NOx (expressed in units of N). To convert to full molecular weights, the emissions of N_2O and NOx are multiplied by 44/28 and 46/14, respectively.

Default values of emission ratios are presented in the following table.

Table 284 Emission ratios for agricultural residue burning calculations

	Emission ratio
CH_4	0.005
N_2O	0.005
CO	0.06
NOx	0.121
Source	Table 4.16, 1996 IPCC GL, Reference Manual, Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues, page 4.83. [187]

Data on carbon content and nitrogen content of residues and the nitrogen-carbon ratio in biomass residues are provided in the following table.

Table 285 C Fraction of Residue, N Fraction of Residue and N-C ratio in Biomass Residue

Fuel	C Fraction of Residue	N Fraction of Residue	N-C ratio in Biomass Residue
	(tonnes of carbon / tonnes of dry matter)	(tonnes of nitrogen / tonnes of dry matter)	(tonnes of carbon / tonnes of nitrogen)
Wheat	0.4853	0.0028	0.0058
Barley	0.4567	0.0043	0.0094
Maize	0.4709	0.0172	0.0365
Rice	0.4144	0.0067	0.0162
Peas	0.4446	0.0142	0.0319
Potatoes	0.4642	0.0168	0.0362
Sugar beet	0.5378	0.0073	0.0136
Cotton	0.4853	0.0150	0.0309
Feetbeet	0.4072	0.0228	0.0560
Peanuts	0.4612	0.0106	0.0230
Sunflower	0.4853	0.0150	0.0309
Source	Table 4.16, IPCC GPG 2000, Chap. 4_Agriculture, page 4.58.[188]	Table 4.19, 1996 IPCC GL, Reference Manual, Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues, page 4.83.[189]	calculated

5.7.3 Uncertainties and time-series consistency for IPCC sub-category 3.F Field burning of agricultural residues

The uncertainties for activity data and emission factors used for IPCC category 3.F Field burning of agricultural residues are presented in the following table.

[187] https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/CH4ref6.pdf
[188] https://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf
[189] https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/CH4ref6.pdf

Table 286 Uncertainty for IPCC sub-category 3.F Field burning of agricultural residues.

Uncertainty	CO_2	CH_4	N_2O	Reference
				2006 IPCC GL, Vol. 4, Chap. 11
Activity data (AD)	-	20%	20%	Expert judgment on Chapter 11.2.1.4
Emission factor (EF)	-	180%	180%	Table 11.1 Chapter 1.2.1.2
Combined Uncertainty	-	181%	181%	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

5.7.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of data on area under crop cultivation (statistical yearbook and FAOstat),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources: national statistic (NSIA) and international statistics (FAO)

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

5.7.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category 3.F Field burning of agricultural residues.

Table 287 Recalculations done since SNC in IPCC sub-category 3.F Field burning of agricultural residues

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
3.F	application of 2006 IPCC Guidelines	method	Comparability
3.F	Revision of Fraction of crop residues burnt in field Revision of Dry matter fraction Consideration of more crops	AD	Comparability Transparency Accuracy

5.7.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 288 Planned improvements for IPCC sub-category 3.F Field burning of agricultural residues

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.F	Correction of technical mistakes in calculation	AD	Accuracy	high
3.F	Consideration of cultivated crops and crop residues which are burnt and if possible, by provinces • Crops where crop residues are burned • Use of crop residues: biofuel, domestic livestock feed, building materials, burning in the field etc. • Dry matter fraction • Estimation of above-ground (and below ground) biomass, dead organic matter (dead wood and litter)	AD	Transparency Accuracy	high
3.F	Cross-check with FAO statistics[190] (Emissions – Agriculture) where emissions from crop residues were estimated		Consistency	medium

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[190] Available (03. March 2019) on http://www.fao.org/faostat/en/#data/GA

5.8 Liming (IPCC category 3.G)

This section the estimation of CO_2 emission from liming. In general liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. The adding of carbonates to soils in the form of lime (e.g., calcic limestone ($CaCO_3$), or dolomite ($CaMg(CO_3)_2$) leads to CO_2 emissions as the carbonate limes dissolve and release bicarbonate ($2HCO_3^-$), which evolves into CO_2 and water (H_2O).

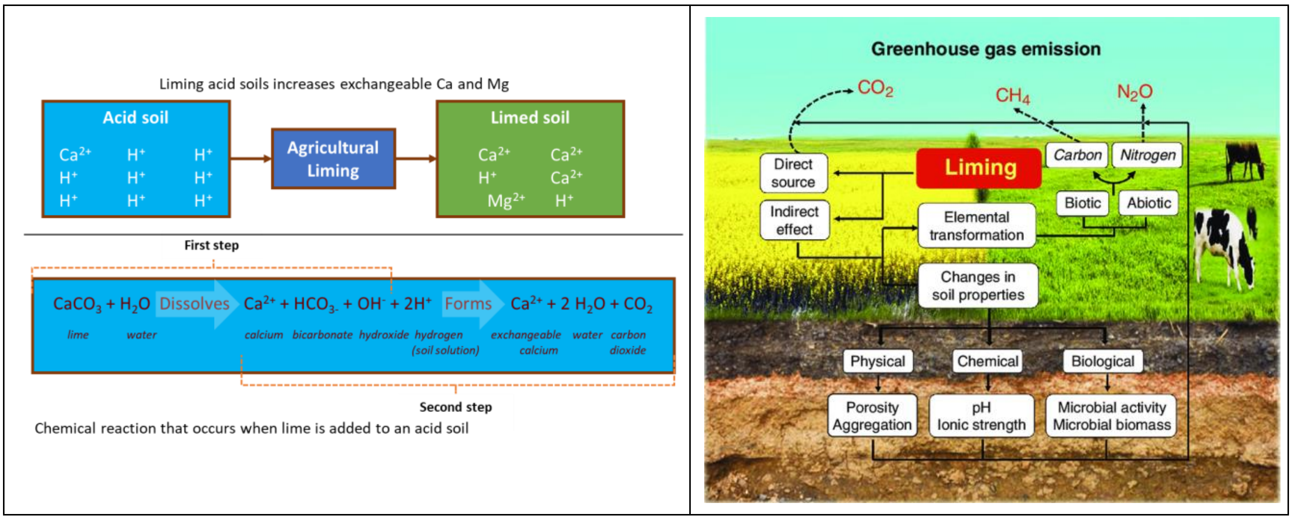

Figure 175 Conceptual flow diagram showing the effect of liming on greenhouse gases

Source (left Figure): Ritchey, E.L.; Murdock, L.W.; Ditsch, D. and McGrath, J.M. (2016): Agricultural Lime Recommendations Based on Lime Quality. In: Plant and Soil Sciences; F.J. Sikora, Division of Regulatory Services. In: Cooperative extension service university of Kentucky College of Agriculture, food and environment, Lexington, KY, 40546. ID-163.

Source (right Figure): Kunhikrishnan, A.; Thangarajan, R. ; Bolan, N.S.; Xu, Y.; Mandal, S.; Gleeson, D.B.; Seshadri, B.; Zaman; M.; Barton; L.; Tang; C.; Luo; J.; Dalal; R.; Ding; W.; Kirkham; M.B.; Naidu; R. (2016): Functional Relationships of Soil Acidification, Liming, and Greenhouse Gas Flux. In: Advances in Agronomy. Volume 139, 2016, Pages 1-71.

GHG emissions from this sector comprise emissions from the following categories:

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.G	**Liming**	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

This source category does not exist in Afghanistan.

5.9 Urea application (IPCC category 3.H)

This chapter includes information on, and description of methodologies used for estimating GHG emissions as well as references to activity data and emission factors reported under IPCC category *Urea application* for the period 1990 to 2017.

As described in the 2006 IPCC GL, Col. 4, Chap. 11, adding urea to soils during fertilisation leads to a loss of CO_2 that was fixed in the industrial production process. 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.

$$(1)\ CO(NH_2)_2 + 2H_2O \xrightarrow{\text{Urease enzyme}} (NH_4)_2CO_3$$

Urea Water Ammonium carbonate

$$(2)\ NH_4)_2CO_3 + 2H^+ \longrightarrow 2NH_4 + CO_2\uparrow + 2H_2O$$

Ammonium carbonate Ammonium Carbon dioxide Water

$$(3)\ NH_4 + OH^+ \longrightarrow Ca(NO_3)_2 + H_2O$$

Ammonium Hydroxide Ammonia Water

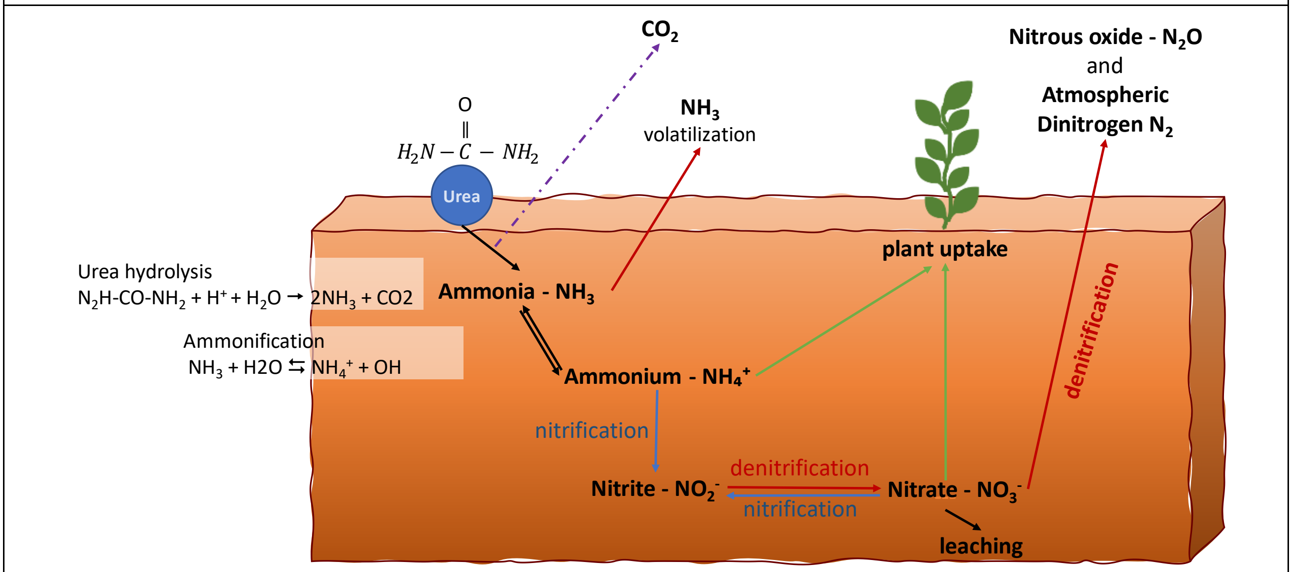

Figure 176 Urea hydrolysis reaction (equation)

This source category is included because the CO_2 removal from the atmosphere during urea manufacturing is estimated in the IPCC sector *Industrial Processes and Product Use Sector (IPPU).*

5.9.1 Source category description

GHG emissions from this sector comprise emissions from the following categories:

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.H	Urea application	✓	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

In 2017, this source category was responsible for 100% of agricultural CO_2 emissions and for 1.31% of the total CO_2 emissions estimated for Afghanistan. It represented 0.3% of the GHG emissions from the agriculture sector and 0.3% of the total GHG emissions in CO_2eq (excluding LULUCF).

In the period 1990 – 2017 the CO_2 emissions increased by 26.4%. In the period 2005 – 2017 the CO_2 emissions increased by 269.0% mainly due to increased area under cultivation and urea application.

The emission of 2015 – 2017 are provisionally as the activity data were not available.

An overview of the methane emissions resulting IPCC category 3.H Urea application is provided in the following figure and table.

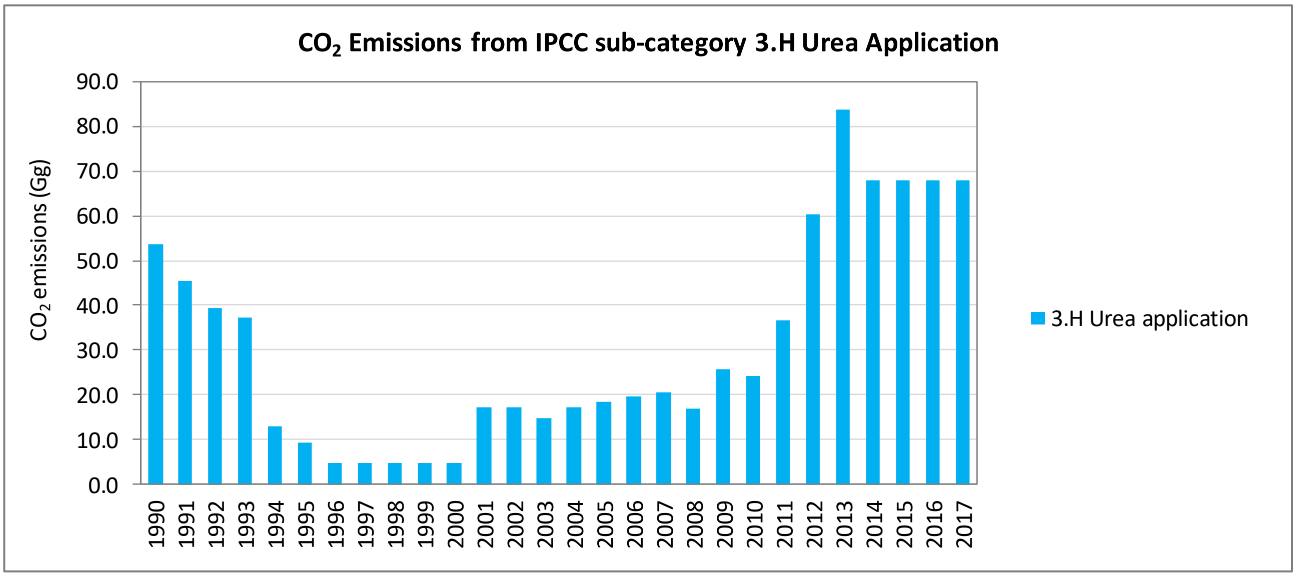

Figure 177 CO_2 Emissions from IPCC sub-category 3.H Urea application

Table 289 Annual amount of urea applied, emission factor and CO_2 emissions from IPCC category 3.H Urea application

Years	Urea application	Emission factor N_2O-N	CO_2-C emissions	CO_2 emissions	Method	EF used
	tonnes	t of C/t of urea	Gg	Gg	Gg	Gg
1990	73,269	0.20	14.65	53.73	T1	D
1991	62,183	0.20	12.44	45.60	T1	D
1992	53,518	0.20	10.70	39.25	T1	D
1993	50,970	0.20	10.19	37.38	T1	D
1994	17,839	0.20	3.57	13.08	T1	D
1995	12,742	0.20	2.55	9.34	T1	D
1996	6,371	0.20	1.27	4.67	T1	D
1997	6,371	0.20	1.27	4.67	T1	D
1998	6,371	0.20	1.27	4.67	T1	D
1999	6,371	0.20	1.27	4.67	T1	D
2000	6,371	0.20	1.27	4.67	T1	D
2001	23,446	0.20	4.69	17.19	T1	D
2002	23,446	0.20	4.69	17.19	T1	D
2003	20,320	0.20	4.06	14.90	T1	D

Years	Urea application	Emission factor N_2O-N	CO_2-C emissions	CO_2 emissions	Method	EF used
	tonnes	t of C/t of urea	Gg	Gg	Gg	Gg
2004	23,383	0.20	4.68	17.15	T1	D
2005	25,096	0.20	5.02	18.40	T1	D
2006	26,651	0.20	5.33	19.54	T1	D
2007	28,205	0.20	5.64	20.68	T1	D
2008	23,289	0.20	4.66	17.08	T1	D
2009	35,236	0.20	7.05	25.84	T1	D
2010	33,159	0.20	6.63	24.32	T1	D
2011	49,936	0.20	9.99	36.62	T1	D
2012	82,116	0.20	16.42	60.22	T1	D
2013	114,296	0.20	22.86	83.82	T1	D
2014	92,616	0.20	18.52	67.92	T1	D
2015	92,616	0.20	18.52	67.92	T1	D
2016	92,616	0.20	18.52	67.92	T1	D
2017	92,616 P	0.20	18.52	67.92	T1	D
Trend						
1990 - 2017	*26%*	-	*26%*	*26%*	-	-
2005 - 2017	*269%*	-	*269%*	*269%*	-	-
2016 - 2017	*0%*	-	*0%*	*0%*	-	-
Source	FaoSTAT-Fertilizers by Product[191] P as of 2016	2006 IPCC GL, Vol. 4, Chap. 11, sub-chap. 11.4.2, page 11.34.	Equation 11.13, 2006 IPCC GL, Vol. 4, Chap. 11, sub-chap. 11.4.1, page 11.32.	Multiplication by 44/12 to convert CO_2–C emissions into CO_2 according to 2006 IPCC GL	Tier 1 (T1)	Default (d)

5.9.2 Methodological issues

5.9.2.1 Choice of methods

TIER 1 approach

For estimating the CO_2 emissions from urea application, the 2006 IPCC Guidelines Tier 1 approach[192] has been applied.

Equation 11.13: CO_2 emissions from urea application
(2006 IPCC GL, Vol. 4, Chap. 11)

$$CO_2 - C\ emission = AD \times EF$$

$$CO_2\ emissions = \frac{CO_2O - C \times \frac{44}{12}}{1000}$$

[191] FAO (2019): Available on 18.04.2018 at: http://www.fao.org/faostat/en/#data/RFB

[192] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11 - N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap. 11.4.1, page 11.32.

Where:

CO_2 emission	= annual CO_2 emissions from urea application (Gg)
CO_2–C emission	= annual C emissions from urea application (tonnes C)
AD	= annual amount of urea fertilisation (tonnes urea)
EF	= emission factor (tonne of C / tonne of urea)
44/12	= conversion factor from C to CO_2
1000	= conversion factor from tonnes to Gg

5.9.2.2 Choice of activity data

The agricultural data used and presented in this inventory are taken from national and international sources:

- FAO agricultural data base[130]

The annual amount of urea in used IPCC sector Agriculture, as presented in Table 290 below, is determined by national production, import and export, as well as 'other uses of urea'.

Agricultural use of Urea **=** production **+** import **–** export **–** Other Uses of Urea

Table 290 Annual amount of urea production, import and export and agricultural use of urea

	Urea Production		Urea Import Quantity		Urea Export Quantity		Other Uses of Urea		Agricultural Use of Urea	
	tons	*Source*	tons	*Source*	tons	*Source*	tons	*Source*	tons	*Source*
1990	No information available		No information available		No information available		No information available		73,269	FaoSTAT-Fertilizers Archive
1991									62,183	
1992									53,518	
1993									50,970	
1994									17,839	
1995									12,742	
1996									6,371	
1997									6,371	
1998									6,371	
1999									6,371	
2000									6,371	
2001									23,446	
2002	23,414	Official data from questionnaires and/	32	(R)	0	(A) Estimated data using trading partners database	0	(Qm)	23,446	Data obtained as a balance
2003	16,206		4,114		0		0		20,320	
2004	19,458		3,925		0		0		23,383	
2005	15,631		9,465	(Qm)	0		0	(Qm)	25,096	
2006	17,636		31,396		0		0		49,032	
2007	16,973		11,232		0		0		28,205	
2008	15,324		7,964		0		0		23,289	
2009	13,606		21,629		0		0		35,236	

	Urea Production		Urea Import Quantity		Urea Export Quantity		Other Uses of Urea		Agricultural Use of Urea	
	tons	*Source*	tons	*Source*	tons	*Source*	tons	*Source*	tons	*Source*
2010	12,022		21,137		0		0		33,159	
2011	17,555		32,381		0		0		49,936	
2012	15,776		202,395		0		0		218,171	
2013	15,694		98,602		0		0		114,296	
2014	14,416		78,200	(E)	0		0	(E)	92,616	
2015	14,416	(Fm)	78,200	(Fm)	0		0		92,616	
2016	14,416		78,200		0		0		92,616	
2017	14,416	(P)	78,200	(P)	0	(P)	0	(P)	92,616	(P)
Trend										
1990 - 2017	*NA*		*NA*		*NA*		*NA*		*NA*	
2005 - 2017	*-8%*		*726%*		*NA*		*NA*		*269%*	
2016 - 2017	*0%*		*0%*		*NA*		*NA*		*0%*	
FaoSTAT-Fertilizers by Product[193]									1990-2001: FaoSTAT-Fertilizers Archive[194] 2002-2016: FaoSTAT-Fertilizers by Product[193]	
Fm Manual Estimation P as of 2016	Qm Official data from questionnaires and/or national sources and/or COMTRADE (reporters) R Estimated data using trading partners database A Aggregate, may include official, semi-official, estimated or calculated data				E Expert sources from FAO (including other divisions) R Estimated data using trading partners database					

5.9.2.3 Choice of emission factors

The default emission factor was taken from IPCC 2006 Guidelines and presented in presented in the following table.

Table 291 CO_2 Emission factor TIER 1 for IPCC category 3.H Urea application

	EF CO_2-C (t of carbon/t of urea)			Source
	Method	EF	type	
Urea application	T1	0.20	D	2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11 - N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap. 11.4.2, page 11.34.
Note: D Default; CS Country specific; PS Plant specific; IEF Implied emission factor				

5.9.3 Uncertainties and time-series consistency for IPCC sub-category 3.D Urea application

The uncertainties for activity data and emission factors used for IPCC category 3.D Urea application are presented in the following table.

[193] FAO (2019): Available on 18.04.2018 at: http://www.fao.org/faostat/en/#data/RFB

[194] FAO (2019): Available on 18.04.2018 at: http://www.fao.org/faostat/en/#data/RA

Table 292 Uncertainty for IPCC sub-category 3.D Urea application.

Uncertainty	CO_2	CH_4	N_2O	Reference
Activity data (AD)	10%	-	-	Table 2.15 and Table 3.1, 2006 IPCC GL, Vol. 2, Chap. 2 (2.4.2)
Emission factor (EF)	50%	-	-	Chapter 11.4.4, 2006 IPCC GL, Vol. 4, Chap. 11
Combined Uncertainty	51%	-	-	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

5.9.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources: national statistic (NSIA) and international statistics (FAO)

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency - plausibility checks of dips and jumps.

5.9.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category 3.H Urea application.

Table 293 Recalculations done since submission 2017 IPCC category 3.H Urea application

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
3.H	No recalculation as this source is estimated the first time	-	-

5.9.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 294 Planned improvements for IPCC sub-category 3.C Urea application

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.H	Cross-check of national data and international data as in this inventory cycle only international data from FAO were used.	AD	Transparency Consistency Comparability	high

5.10 Other carbon-containing fertilizers (IPCC category 3.I)

GHG emissions from this sector comprise emissions from the following categories:

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.I	Other carbon-containing fertilizers	No	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

This source category does not exist in Afghanistan.

5.11 Other (IPCC category 3.J)

GHG emissions from this sector comprise emissions from the following categories:

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.J	Other	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

This source category does not exist in Afghanistan.

6 AFOLU - Land Use, Land Use Change and Forestry (IPCC sector 3)

Justification for not estimating emissions by sources and removals by sinks from IPCC sector LULUCF in this inventory cycle

The IPCC sector LULUCF (Land Use, Land-Use Change and Forestry) includes GHG emissions by sources and removals by sinks resulting from managed land and land-use changes. According to the 2006 IPCC Guidelines six land-use categories form the basis of estimating and reporting greenhouse gas emissions and removals from land use and land-use conversions:

- **4.A Forest land;**
- **4.B Cropland;**
- **4.C Grassland;**
- **4.D Wetland;**
- **4.E Settlement;**
- **4.F Other land.**

This land categories can further disaggregate to

- **land remaining** in the **same land-use category** (e.g. forest land remaining forest land)
- **land converted to another land-use category** (e.g. grassland converted to forest).

For each of these land categories **greenhouse gases CO_2, CH_4 and N_2O** have to be estimated. Furthermore, the **carbon stock changes** within the stratum (homogeneous population, e.g. vegetation, management practices) has to be estimated by considering the carbon cycle processes between the five **carbon pools**

   - **living biomass – above-ground and below-ground;**
   - **dead organic matter (DOM);**
   - **litter;**
   - **soil organic matter (SOM).**

Finally, the estimates of carbon emissions and removals involve two factors:

1. **Activity Data** - the amount of area undergoing a specific transition;

2. **Emissions Factor** - the change in carbon pools association with that transition.

In Afghanistan the preparation of GHG emissions by sources and removals by sinks from IPCC sector LULUCF is currently not possible as no sufficient data for none of the three **methodologies to represent areas of land use** using the above-mentioned land-use categories were available.

The quality objectives TACCC of an inventory transposed to **Land representation** provides/presents guidance to make best use of available data and reducing possible overlaps and omissions (in reporting). Generally, data used in the LULUCF inventory should be

- **adequate (accurate):** capable of representing land-use categories, and conversions between land-use categories, as needed to estimate carbon stock changes and greenhouse gas emissions and removals;
- **consistent:** capable of representing land use categories consistently *across time*;

- **complete:** all land area within the country is included with consideration of increases in some areas balanced by decreases in others and reorganization of bio-physical stratification of land if needed;
- **comparable:** categories suitable to be aggregated according to the IPCC default categories.
- **transparent:** data sources, definitions, methodologies and assumptions should be clearly described.

In order to fulfil the above-mentioned definition, requirements and criteria, the available national and international data available for Afghanistan have been reviewed.

The land representation prepared **according to TIER 1 Approach requires a time-series for each land-use category**. This means that no information regarding to area of conversions between land uses is needed.

Information of different land-uses is available for the time series

- 1995 – 2017, provided by NSIA[195],
- 1961 – 2017, provided by FAOSTAT[196].

Besides that, the national and international data are not fully consistent, not all land-use categories could be identified. The land-use categories Settlements, Wetlands and Other lands (barren land) are aggregated to 'Other lands".
Furthermore, no change in the area over the period could be observed for the following land-use categories

- Forests and woodland
- Grassland - Permanent pasture
- All other land (Settlements, Wetlands and Other lands (barren land))

No change in the area over the period leads to zero emissions and/or removals.

Only for in the land-use category Cropland, which is about 12 % of the territory of Afghanistan, changes in area could until 2001 be observed. When estimating emissions and removals from LULUCF in the next inventory cycle a further differentiation between permanent and perennial crops could be made.

The land representation prepared **according to TIER 2 Approach and/or TIER 3 Approach requires** information on **land-use conversions between categories,** for TIER 3 Approach requires information on land-use conversions between categories on a spatially explicit basis. Additionally, it has to be taken into account the length of time that land remains in a conversion category after a change in land use which is by default 20 years.

For Afghanistan four **Land cover databases and maps** are available and relevant shape file can be downloaded from the FAO website[197].

- Land cover database for 1972 Available on FAO website[198]
- Land cover database for 1993 Available on FAO website[199]
- Land cover database for 2010 Available on FAO website [200]

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195 NSIA. (2019): Agriculture data. Available on 20.02.2019 at: http://cso.gov.af/en/page/economy-statistics/economy/agriculture
196 FAO (2019): Available on 20.02.2019 at: http://www.fao.org/faostat/en/#data/GL
197 FAO (2019): Available on 20.04.2019 at: http://dwms.fao.org/~draft/lc_main_en.asp
198 FAO (2019): Available on 20.04.2019 at: http://www.fao.org/geonetwork/srv/en/main.home?uuid=c1b6b150-88fd-11da-a88f-000d939bc5d8
199 FAO (2019): Available on 20.04.2019 at: http://www.fao.org/geonetwork/srv/en/main.home?uuid=c1b18130-88fd-11da-a88f-000d939bc5d8
200 FAO (2019): Available on 20.04.2019 at: http://www.fao.org/geonetwork/srv/en/main.home?uuid=5879a4f0-8fdf-4c93-b39a-02d6ce69ae6d

- Land cover database for 2016 Based on 2010 database [201]

Furthermore, the Global Forest Resources Assessment (FRA) Country Reports for Afghanistan which are prepared on regular basis, are available for the years 1963, 1970, 1976, 1982, 2005, 2010 and 2015 on the website of FAO[202].

The essential feature of TIER 2 Approach 2 and 3 is that they provide an assessment of both the net losses or gains in the area of specific land-use categories and what these conversions represent. **For the preparation of the land-use conversion matrix requires estimation of initial and final land-use categories for all conversion types, as well as of total area of unchanged land by category.**

- The landcover database 1972 had to be excluded, as the focus of the land cover was on agricultural land. Forest land, wetlands, settlements and Other lands are summarized in "Other/ non specified". Therefore, information of the initial land-use categories are from 1993 and of the 'final' land-use categories from 2010.

This means that no information is available with regards to

- the 20 years prior to the initial land-use categories of 1993,
- the period 2010 – 2017 has to be extrapolated.

A preparation of the land-use conversions matrix using the land cover databases 1993 and 2010 is difficult as the subcategories (aggricodes) of the two land cover databases vary widely in some cases. A comparison of the area of the different land-use categories (e.g. cropland) derived from the landcover database are not consistent with official statistics on land use published by NSIA. Expert judgement is required to validate the land-use conversions matrix with official statistics on land use.

Through all the above-mentioned obstacles a reliable land-use conversions matrix could not prepared.

6.1.1 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category *4. LULUCF*.

Table 295 Recalculations done since SNC in IPCC sub-category 4 LULUCF

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
4	Application of 2006 IPCC Guidelines:	method	Accuracy, comparability

6.1.2 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

[201] FAO (2016): Available (14.04.2019) on http://www.fao.org/3/a-i5043e.pdf
[202] FAO (2019): Available on 20.04.2019 at: http://www.fao.org/forest-resources-assessment/en/

Table 296 Planned improvements for IPCC sub-category 4 LULUCF

IPCC code	Planned improvement	Improvement	Type of improvement		Priority
4 LULUCF General	Development a national land classification system applicable to all six land-use categories (Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land) and further subdivide by climate, soil type and/or ecological regions (i.e., strata) • land use definitions • Land cover classification and Land cover data/map covering information 20 years before 1990 or 2005 • Climate classification based on elevation, mean annual temperature (MAT), mean annual precipitation (MAP), mean annual precipitation to potential evapotranspiration ratio (MAP: PET), and frost occurrence. • ecological zones • soil classification for mineral soil types based on USDA taxonomy • area burned information of type, age and condition of biomass	Emission and removals from LULUCF Complete data set including information including historical data Improvement of (agricultural) statistics including historical data (time series development) Country-specific parameter and emissions factors Input data for TIER 1 / TIER 2 methodology	AD EF method	Transparency Accuracy Completeness Comparability Consistency	High

4 LULUCF Forest	Survey and/or research with consideration of (a) regional and district diversity, (b) characterisation by climate and/or soil type and/or (c) ecological regions (i.e., strata)
	• Estimates of land areas remaining forest and converted to Forest
	• Forest inventory and/or forest management system/Area of plantation/forests
	• Area annually affected by disturbances including frequency of disturbances (pest and disease outbreaks, flooding, fires, etc.).
	• Area annually affected by harvest (harvest categories, commercial harvest, fuelwood consumption, traditional fuelwood use and other wood use.)
	• Assessment of changes in carbon stock in DOM
	• Conversion of
	  o unmanaged to managed forest;
	  o native forest into a new forest type;
	• Intensification of forest management activities (i.e. site preparation, tree planting and rotation length changes; changes in harvesting practices
	Harvested Wood Products: Waste deposit, sawn wood, wood panels, paper, energy purpose
		Improvement of agricultural statistics including historical data (time series development)
		Country-specific parameter and emissions factors
		Input data for TIER 1 / TIER 2 methodology
			AD
			EF
				Transparency
				Accuracy
				Completeness
				Comparability
				Consistency
					High

4 LULUCF Cropland	Survey and/or research with consideration of (a) regional and district diversity, (b) characterisation by climate and/or soil type and/or (c) ecological regions (i.e., strata) • estimates of land areas remaining cropland or converted to Cropland • information on Cropland	Improvement of agricultural statistics including historical data (time series development) Country-specific parameter and emissions factors	AD EF	Transparency Accuracy Completeness Comparability Consistency	High

IPCC code	Planned improvement	Improvement	Type of improvement		Priority
	○ arable and tillable land, rice fields, and agroforestry systems ○ annual and perennial crops as well as temporary fallow land ○ crop-pasture rotation (mixed system) land areas of growing stock and harvested land with perennial woody crops including information of Broad subcategories (i.e. fruit orchards, plantation crops, agroforestry system) and related Specific subcategories	Input data for TIER 1 / TIER 2 methodology			
4 LULUCF Grassland	Survey and/or research with consideration of (a) regional and district diversity, (b) characterisation by climate and/or soil type and/or (c) ecological regions (i.e., strata) • estimates of land areas remaining grassland or converted to grassland • share of land-use categories: Steppe/tundra/prairie grassland, Semi-arid grassland, Sub-tropical/ tropical grassland, Woodland/Savannah, Shrubland • information on use/management systems area under managed organic soils	Improvement of agricultural statistics including historical data (time series development) Country-specific parameter and emissions factors Input data for TIER 1 / TIER 2 methodology	AD EF	Transparency Accuracy Completeness Comparability Consistency	high
4 LULUCF Wetland	Survey and/or research with consideration of (a) regional and district diversity, (b) characterisation by climate and/or soil type and/or (c) ecological regions (i.e., strata) • Estimates of land areas remaining wetland or converted to wetland • Wetland use, protection and wetland management • Area under managed organic soils Peat extraction	Improvement of agricultural statistics including historical data (time series development) Country-specific parameter and emissions factors Input data for TIER 1 / TIER 2 methodology	AD EF	Transparency Accuracy Completeness Comparability Consistency	high
4 LULUCF Settlements	Survey with consideration of (a) regional and district diversity, (b) characterisation by climate and/or soil type and/or (c) ecological regions (i.e., strata) • estimates of land areas remaining settlement or converted to settlement information on use/management systems	Improvement of agricultural statistics including historical data (time series development) Country-specific parameter and emissions factors Input data for TIER 1	AD	Transparency Accuracy Completeness Comparability Consistency	high
4 LULUCF Other land	Survey and/or research with consideration of (a) regional and district diversity, (b) characterisation by climate and/or soil type and/or (c) ecological regions (i.e., strata) • estimates of land areas remaining Other land or converted to Other Land information on the use/management system	Improvement of agricultural statistics including historical data (time series development) Country-specific parameter and emissions factors Input data for TIER 1 / TIER 2 methodology	AD EF	Transparency Accuracy Completeness Comparability Consistency	high

7 Waste (IPCC sector 5)

7.1 Overview of sector

This chapter includes information on, and description of methodologies used for estimating GHG emissions, as well as references to activity data and emission factors reported under IPCC Sector *5 – Waste* for the period 1990 to 2017. In the Waste sector emissions of CO_2, CH_4 and N_2O originate from the IPCC categories:

- 5.A Solid waste disposal,
- 5.B Biological treatment of solid waste,
- 5.C Incineration and open burning of waste,
- 5.D Wastewater treatment and discharge.

Emissions from the IPCC sector Waste are a small source of GHGs in Afghanistan:

- in 1990 about 5.2% of the total national GHG emissions and 0.1% of total CO_2 emissions arose from the waste sector, whereas N_2O and CH_4 emissions make up about 8.6% and 3.5%, respectively.
- in 2005 about 5.3% of the total national GHG emissions and 0.1% of total CO_2 emissions arose from the waste sector, whereas N_2O and CH_4 emissions make up about 8.3% and 3.1%, respectively.
- in 2017 about 3.5% of the total national GHG emissions and 0.1% of total CO_2 emissions arose from the waste sector, whereas N_2O and CH_4 emissions make up about 7.7% and 3.7%, respectively.

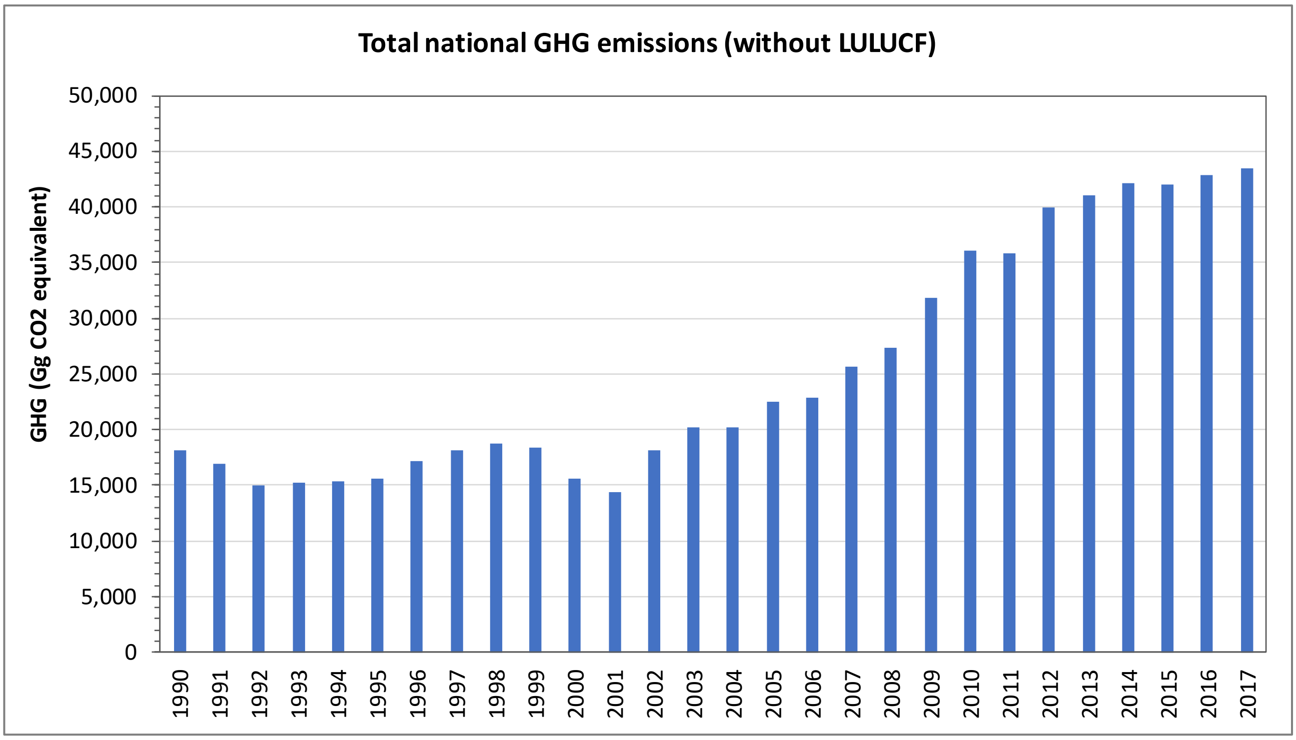

Figure 178 Trend of GHG emissions from 1990 – 2017 for waste

7.1.1 Emission trends

In the period 1990 to 2017 GHG emissions from the Waste Sector increased by 60% from 937.70 Gg CO_2 eq in 1990 to 1,502.27 Gg CO_2 eq in 2017. Emissions from the Waste sector increased by 26% to 1,186.15 Gg

CO_2 equivalents in 2005. In the period 2005 to 2017 GHG emissions from the Waste sector increased by 27%. The increase of emissions is mainly caused by increasing emissions from *Solid waste Disposal* (IPCC subcategory 5.A) and *Incineration and Open Burning of Waste* (IPCC subcategory 5.C).

In the period 2016 to 2017 GHG emissions from the Waste Sector increased by 3.8% from 1,446.59 Gg CO_2 eq in 2016 to 1,502.27 Gg CO_2 eq in 2017, which is mainly caused by increasing emissions from *Solid waste Disposal* (IPCC subcategory 5.A).

The most important sources of GHGs in the Waste Sector is *Solid waste Disposal*. With regards to CO_2 emission, the source *Incineration and open burning of waste* was the primary source. With regards to CH_4 emission and N_2O emission, the source *Solid waste Disposal* was the primary source.

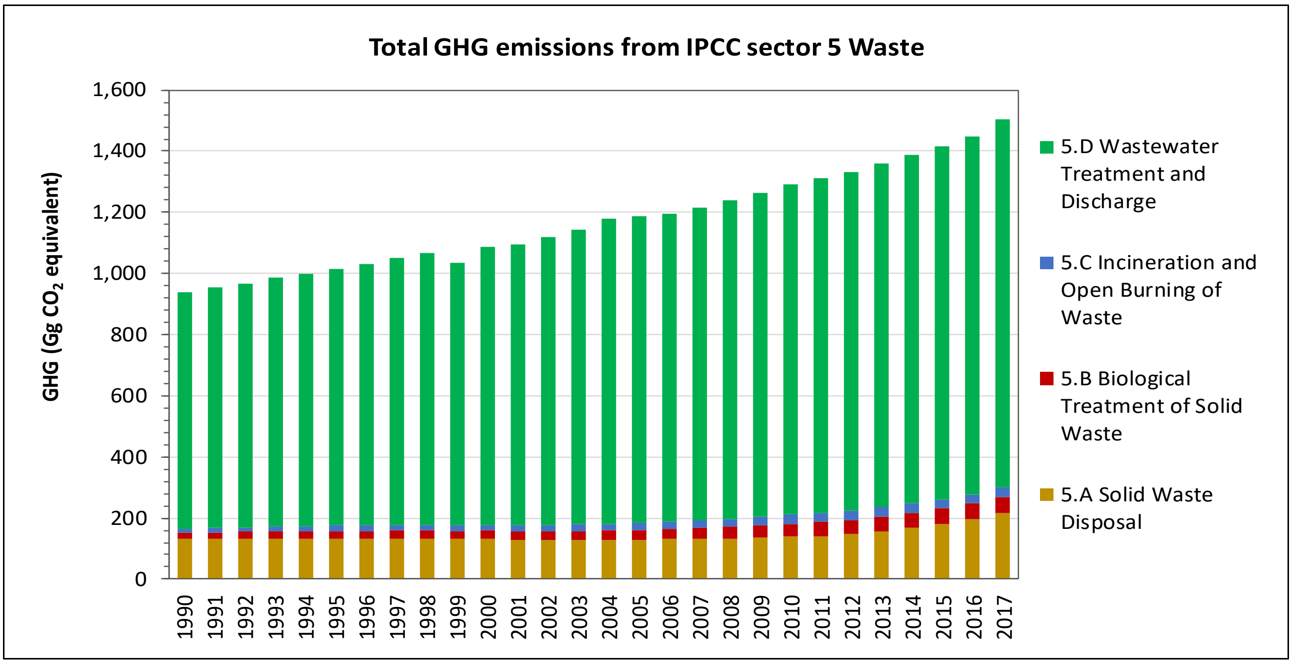

Figure 179 Total national GHG emissions by category of sector Waste (1990-2017)

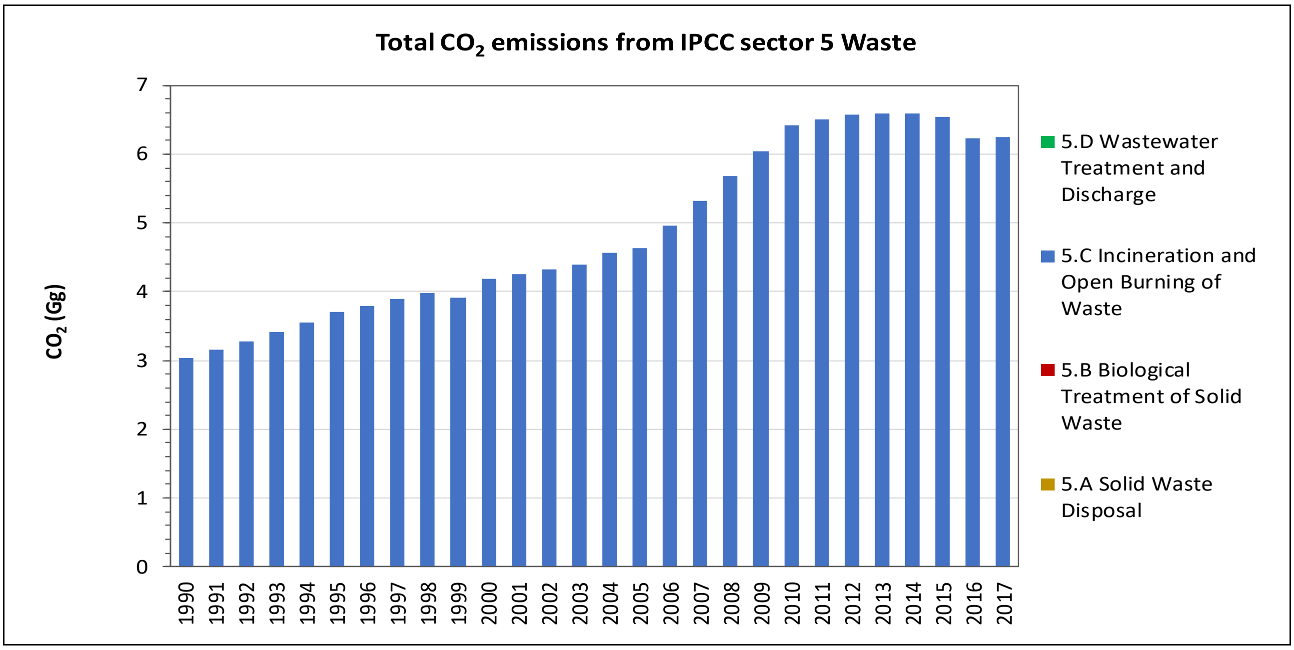

Figure 180 Total national CO_2 emissions by category of sector Waste (1990-2017)

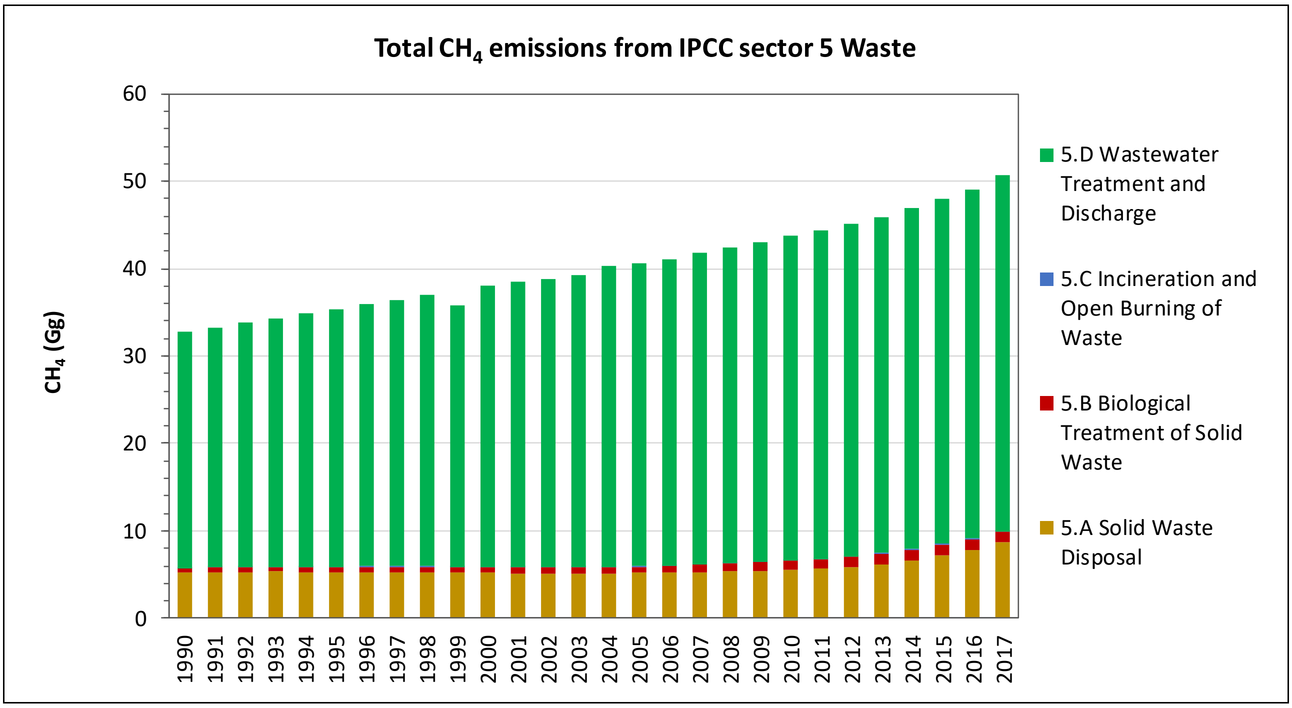

Figure 181 **Total national CH_4 emissions by category of sector Waste (1990-2017)**

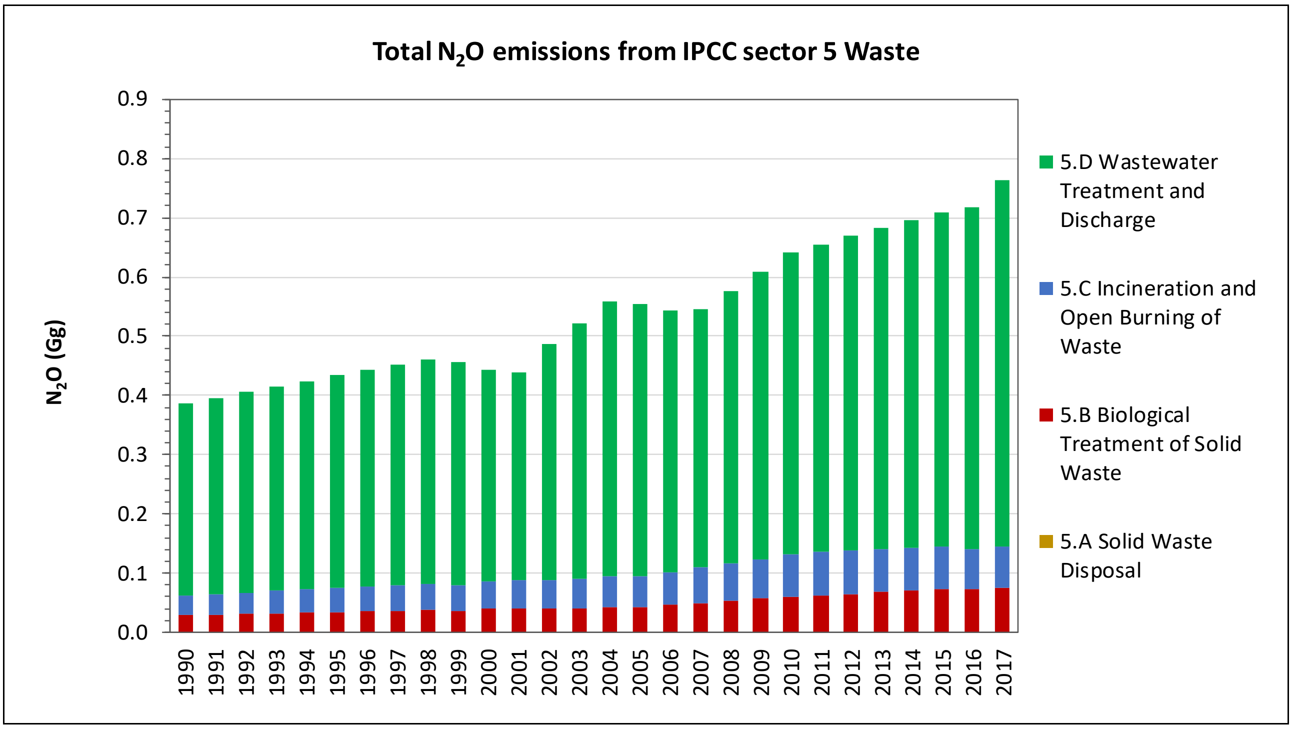

Figure 182 **Total national N_2O emissions by category of sector Waste**

Table 297 Emissions from IPCC sector 5 Waste

GHG emissions	TOTAL GHG	CO_2	CH_4	N_2O	CH_4	N_2O
	Gg CO_2 equivalent	Gg	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg	Gg
1990	937.70	3.03	32.77	0.39	819.16	115.51
1991	952.78	3.15	33.26	0.40	831.48	118.14
1992	968.60	3.28	33.78	0.41	844.46	120.86
1993	984.79	3.42	34.31	0.41	857.74	123.63
1994	1,000.63	3.56	34.82	0.42	870.60	126.48
1995	1,016.40	3.70	35.33	0.43	883.29	129.40
1996	1,032.69	3.79	35.87	0.44	896.87	132.03
1997	1,049.12	3.89	36.42	0.45	910.52	134.71
1998	1,065.72	3.98	36.97	0.46	924.28	137.46
1999	1,036.42	3.91	35.87	0.46	896.68	135.83
2000	1,088.18	4.19	38.08	0.44	951.88	132.11
2001	1,096.63	4.26	38.46	0.44	961.52	130.86
2002	1,120.27	4.33	38.85	0.49	971.17	144.77
2003	1,142.19	4.40	39.30	0.52	982.50	155.29
2004	1,178.49	4.56	40.30	0.56	1,007.42	166.51
2005	1,186.15	4.63	40.64	0.56	1,016.07	165.45
2006	1,194.84	4.96	41.12	0.54	1,027.92	161.96
2007	1,215.03	5.32	41.89	0.55	1,047.19	162.52
2008	1,239.28	5.67	42.47	0.58	1,061.83	171.78
2009	1,264.40	6.04	43.08	0.61	1,077.04	181.32
2010	1,290.51	6.41	43.72	0.64	1,092.92	191.18
2011	1,310.77	6.50	44.36	0.66	1,108.90	195.37
2012	1,333.39	6.56	45.09	0.67	1,127.32	199.50
2013	1,358.72	6.59	45.94	0.68	1,148.57	203.56
2014	1,386.69	6.58	46.90	0.70	1,172.56	207.55
2015	1,417.30	6.53	47.97	0.71	1,199.33	211.44
2016	1,446.59	6.22	49.06	0.72	1,226.62	213.75
2017	1,502.27	6.25	50.73	0.76	1,268.27	227.75
Trend 1990 - 2017	*60.2%*	*106.2%*	*54.8%*	*97.2%*	*54.8%*	*97.2%*
Trend 2005 - 2017	*26.7%*	*35.0%*	*24.8%*	*37.7%*	*24.8%*	*37.7%*
Trend 2012 - 2017	*12.7%*	*-4.8%*	*12.5%*	*14.2%*	*12.5%*	*14.2%*
Trend 2016 - 2017	*3.8%*	*0.4%*	*3.4%*	*6.6%*	*3.4%*	*6.6%*

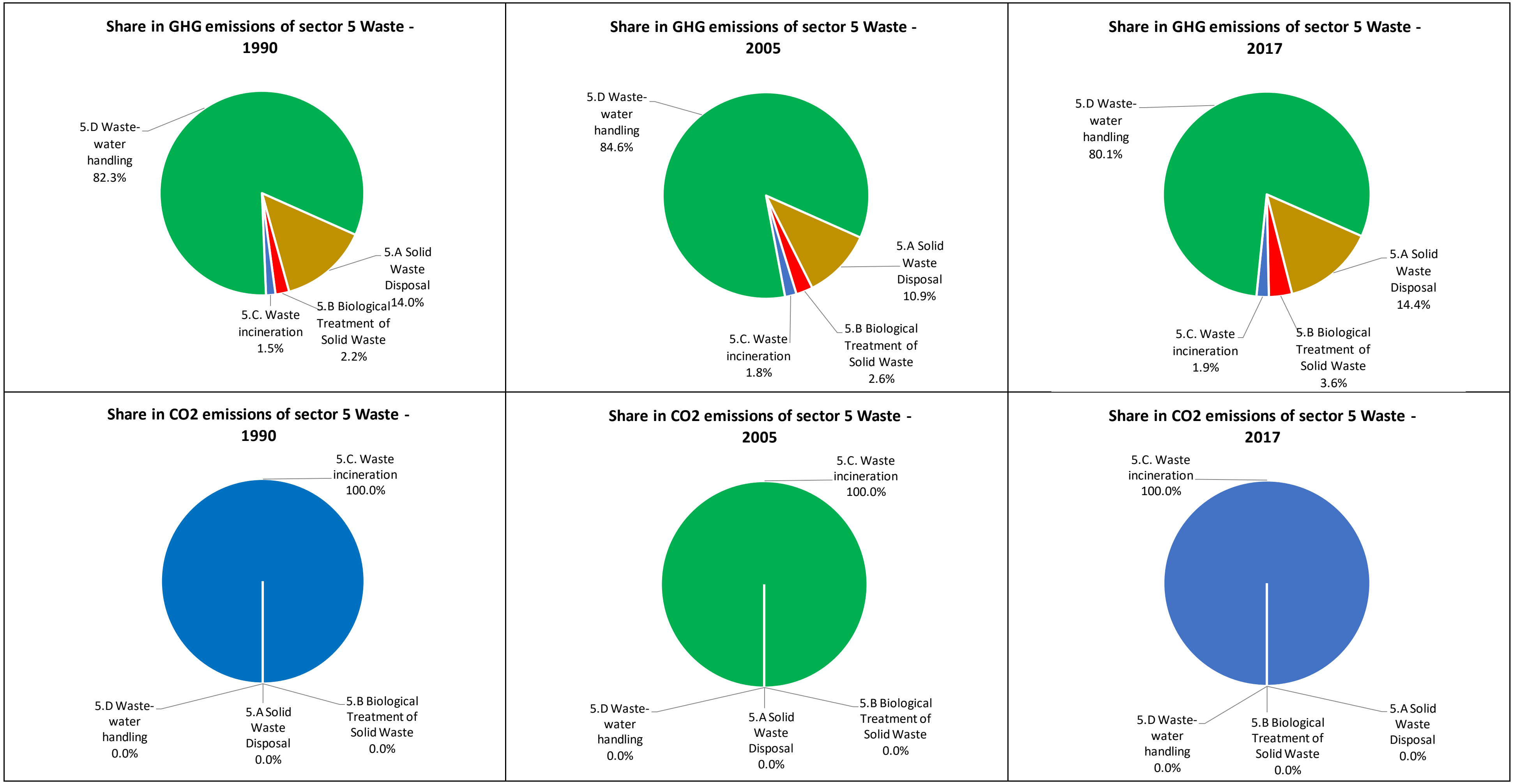

Figure 183 Share of GHG and CO_2 emissions in Sector 5 Waste in 1990, 2005 and 2017

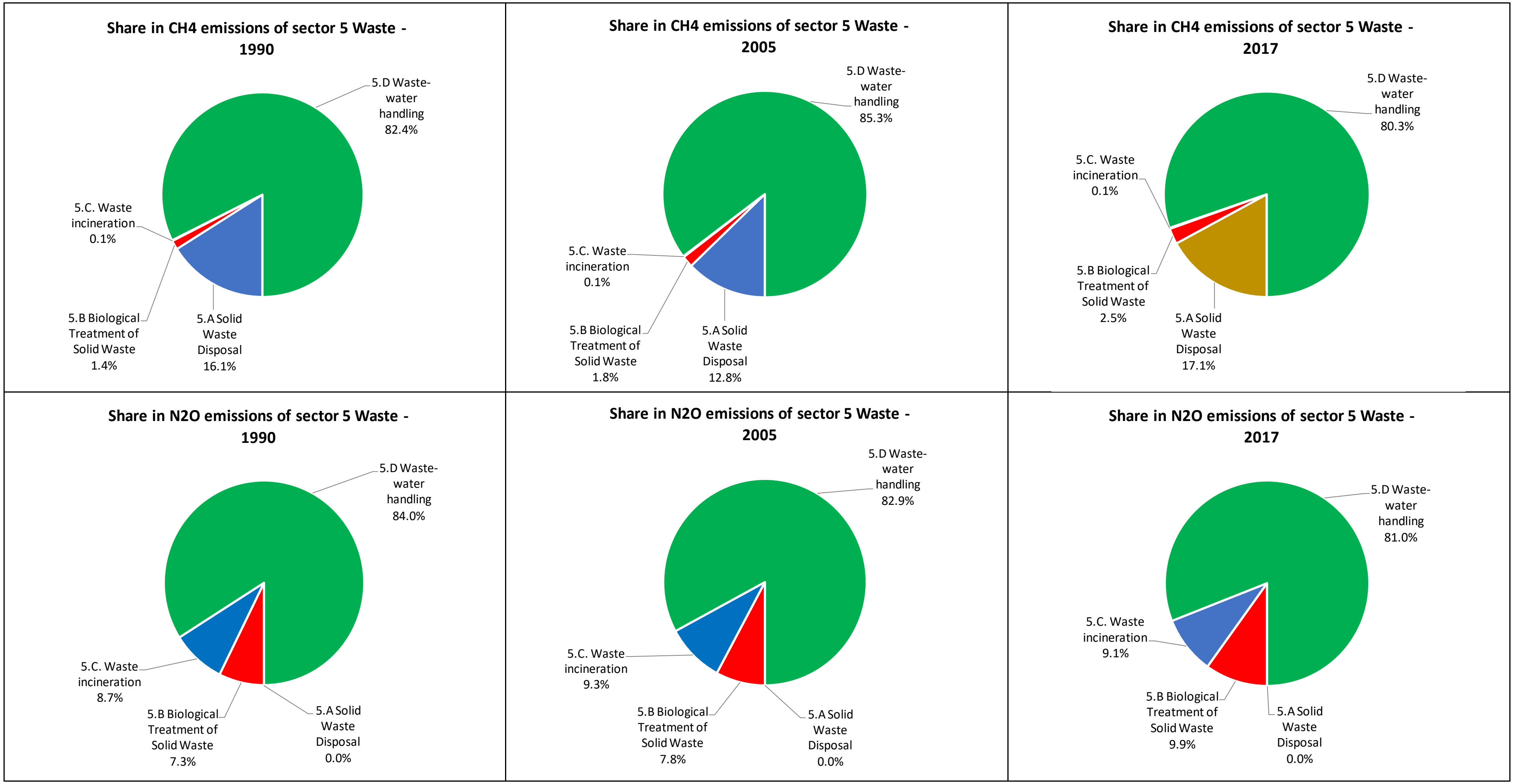

Figure 184 Share of CH_4 and N_2O emissions in Sector 5 Waste in 1990, 2005 and 2017

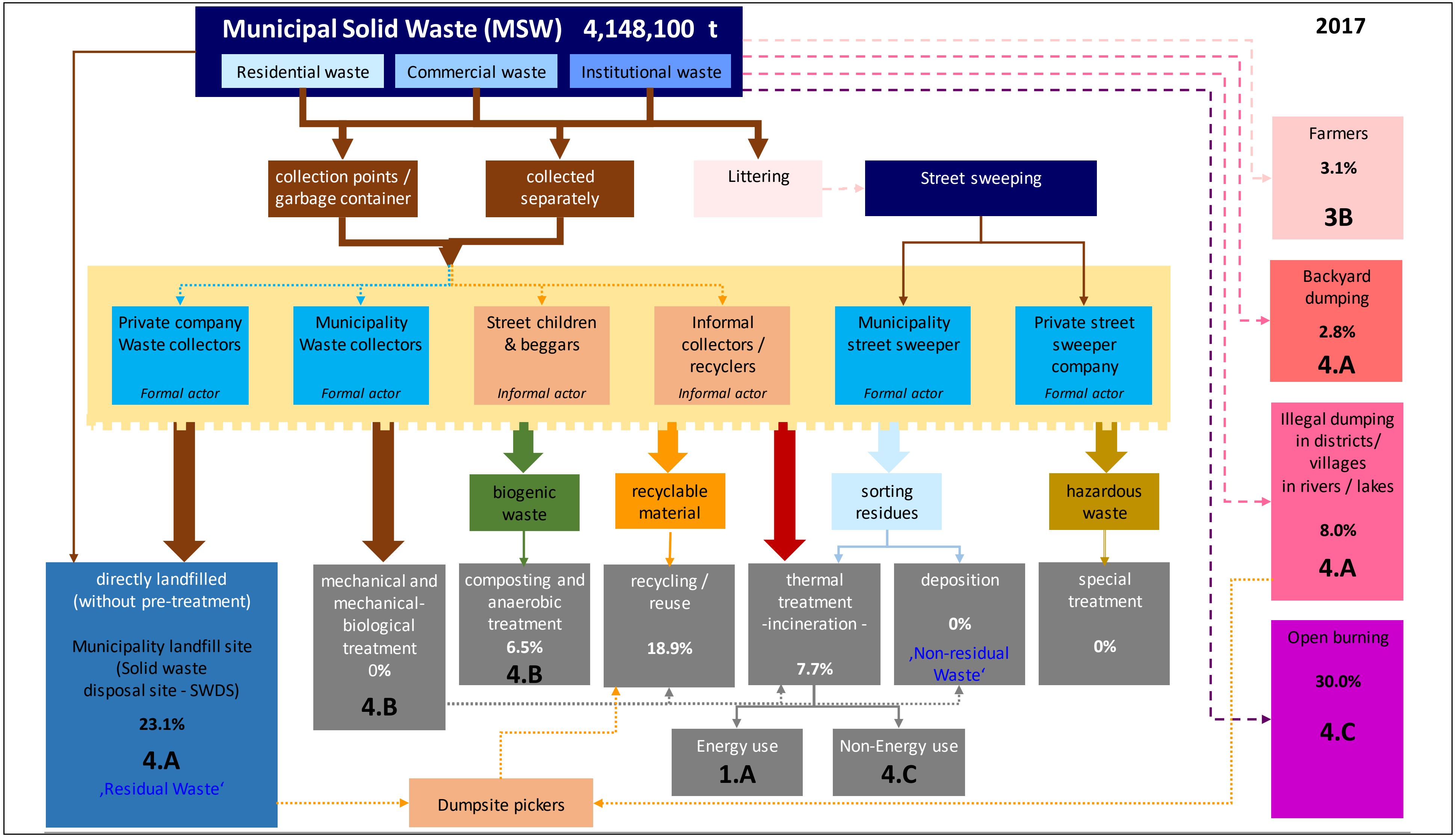

Figure 185 **Waste from households and similar sources: collection process, disposal routes and treatments 2017.**

Please note: This illustration only covers data from households and similar sources. Waste from industrial and similar sources (e.g. wastewater treatment plants) are also included in the inventory, but not considered in this Figure.

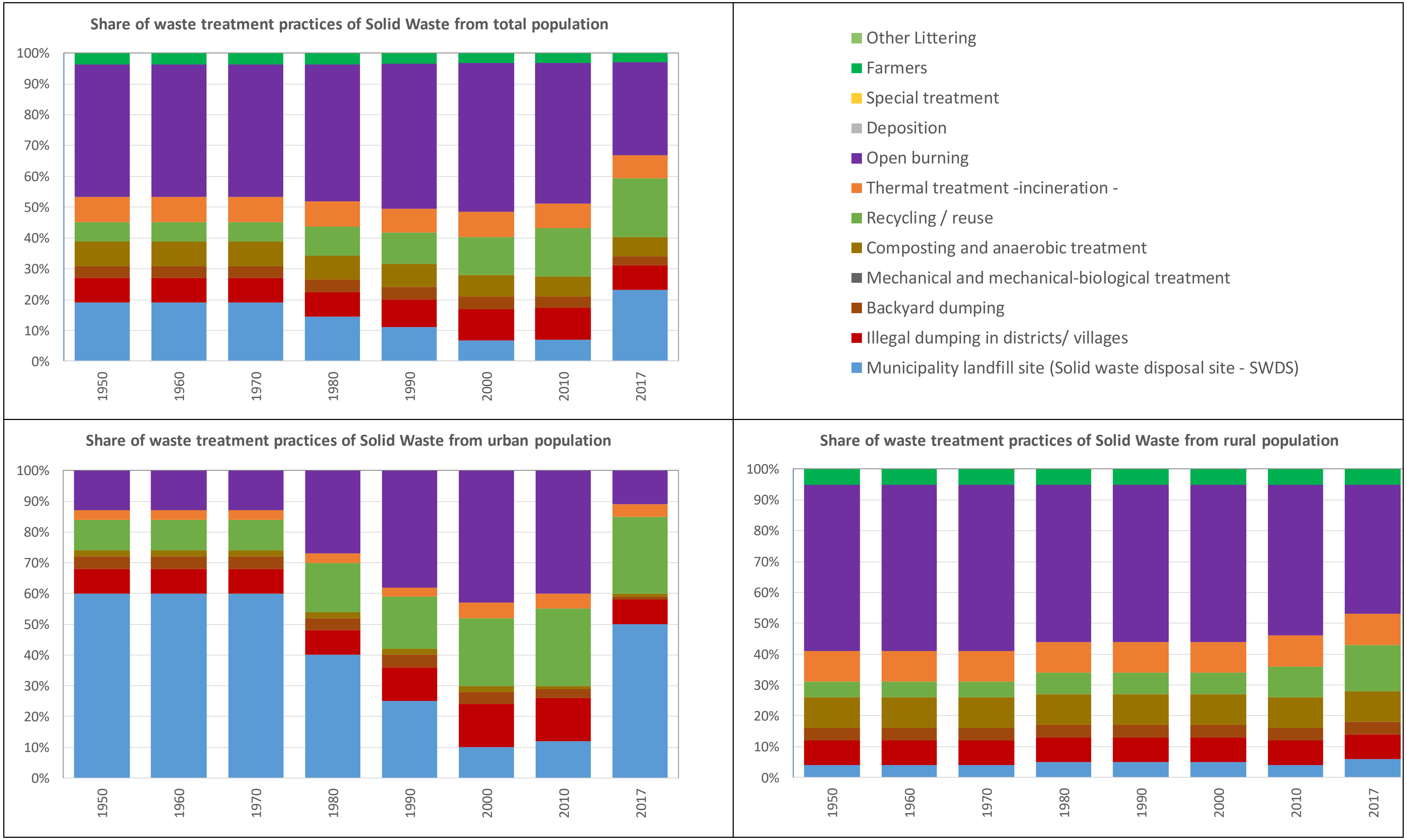

Figure 186 Share of waste treatment practices (aggregated) of Solid Waste from total, urban and rural population for the pillar years

7.1.2 Country-specific issues

Waste management has become a complex area legally, technically and commercially. Solid waste generation rates and composition vary from country to country depending on the economic situation, industrial structure, waste management regulations and lifestyle. Afghanistan still have a number of issues that need to be resolved related to solid waste management. Municipal administrations and mayors receive their mandate to manage municipal affairs through the current Municipal Law created in 2000. According to the current municipal law, municipalities are public legal and juristic entities given the task to provide for the general needs of urban populations.[203]

According to 2006 IPCC Guidelines it is *good practice* to account for all types of solid waste when estimating waste-related emissions in the greenhouse gas inventory. The availability and quality of data on solid waste generation as well as subsequent treatment vary significantly from country to country. In Afghanistan statistics on waste generation and treatment have been improved substantially during the last 10 years, but there is still gap in comprehensive waste data covering all waste types and treatment techniques. Therefore, an overall analysis was made of the collection process, disposal routes and various treatments techniques. The following steps were done

Step 1 - Definition of solid waste;

Step 2 - Waste collection and waste disposal routes: Identification of waste treatments and allocation the waste to the waste treatments;

Step 3 - Compilation of activity data on waste generation per year starting from 1950;

Step 4 - Estimation of GHG emission from the different waste treatments techniques.

7.1.2.1 Definition of solid waste

Solid waste is generated from households, offices, shops, markets, restaurants, public institutions, industrial installations, water works and sewage facilities, construction and demolition sites, and agricultural activities.

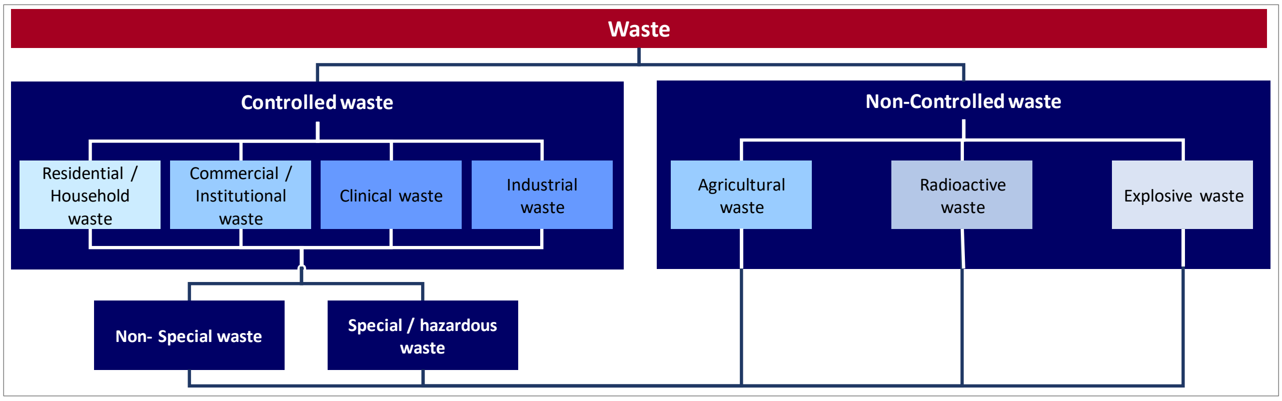

Figure 187 Definition of Waste

203 The current law lists 44 functions of municipalities. For the full list see: Popal, A. B. (2014) Municipalities in Afghanistan. IDLG/GDMA, pgs. 18-20. Available (16. January 2019) on http://dmm.gov.af/Content/files/Municipalities%20in%20Afghanistan_final.pdf

Solid waste fractions can be divided in the following fractions:

- Municipal Solid Waste (MSW) is generally defined as waste collected by municipalities or other local authorities. In Afghanistan MSW includes
  - household waste;
  - garden (yard) and park waste; and
  - commercial/institutional waste
  - construction and demolition waste.
- Sludge which comes from domestic and industrial wastewater treatment plants.
- Industrial waste from different industrial sectors. In Afghanistan industrial waste is not managed as a specific stream and the waste
- Clinical waste includes materials like plastic syringes, animal tissues, bandages, cloths, etc. In Afghanistan clinical waste is still disposed in SWDS.
- Hazardous waste which mainly consists out of waste oil, waste solvents, ash, cinder and other wastes with hazardous nature, such as flammability, explosiveness, causticity, and toxicity. In Afghanistan hazardous wastes is not collected, treated and disposed separately from non-hazardous MSW and industrial waste streams. Some hazardous waste is exported for recycling (e.g. batteries).[204]
- Agricultural waste, which is manure management and burning of agricultural residues, is considered in the agriculture sector.

7.1.2.2 Waste collection and waste disposal routes: waste treatments and related allocation

Waste collection and waste disposal routes: Identification of waste treatments and allocation of the waste to the related waste treatments

In Figure 185 the collection process and the different disposal routes and treatments techniques are illustrative presented. Solid waste management practices include collection, recycling, solid waste disposal on land, biological and other treatments as well as incineration without and with energy recovery and open burning of waste. Composting and the use of waste in agriculture needs also to be considered.

7.1.2.3 Compilation of activity data on Municipal Solid Waste (MSW) generation per year starting from 1950

Waste generation is the product of the per capita waste generation rate - *tonnes / capita/year* or *kg / capita / day* - for each component and population. Historical data on waste generation are necessary to estimate GHG emissions from the different waste treatments techniques (see chapter 7.1.2.5) which also reflects changes in waste management practices (e.g., site covering, compacting, etc.). For estimating CH_4 emission from solid waste disposal requires data on

- waste generation of MSW for the last 50 years, starting in 1950;
- waste generation of sludge for the last 50 years, starting in 1950;
- waste generation of industrial waste for the last 50 years, starting in 1950;
- recycling rate, starting in 1950;
- for all other treatment techniques - open burning and/or incineration, composting, anerobic treatment, mechanical and/or mechanical-biological treatment, data is required for the first inventory year, which is 1990.

[204] Basel Convention National Reports - Year 2017 - Afghanistan - Reporting database; Available (16.March 2019)
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

7.1.2.4 Population of Afghanistan 1950 - 2017

The main source of activity data – population by settlement is NSIA and UN statistic. Historical data on total population could obtained for

- 1950 – 1975 from United Nations, Department of Economic and Social Affairs (DESA), Population Division: World Population Prospects 2017[205] (with five-year intervals);
    - For those years data were not available interpolation was be used;
    - The split in urban and rural population was taken from 1979 data.
- 1979 – 2004 from United Nations, Statistics Division, Demographic Statistics Database: Population by religion, sex and urban/rural residence[206];
- 2004 - 2017 from National Statistics and Information Authority (NSIA) of Afghanistan, Settled Population by civil division (Urban and Rural)[207].

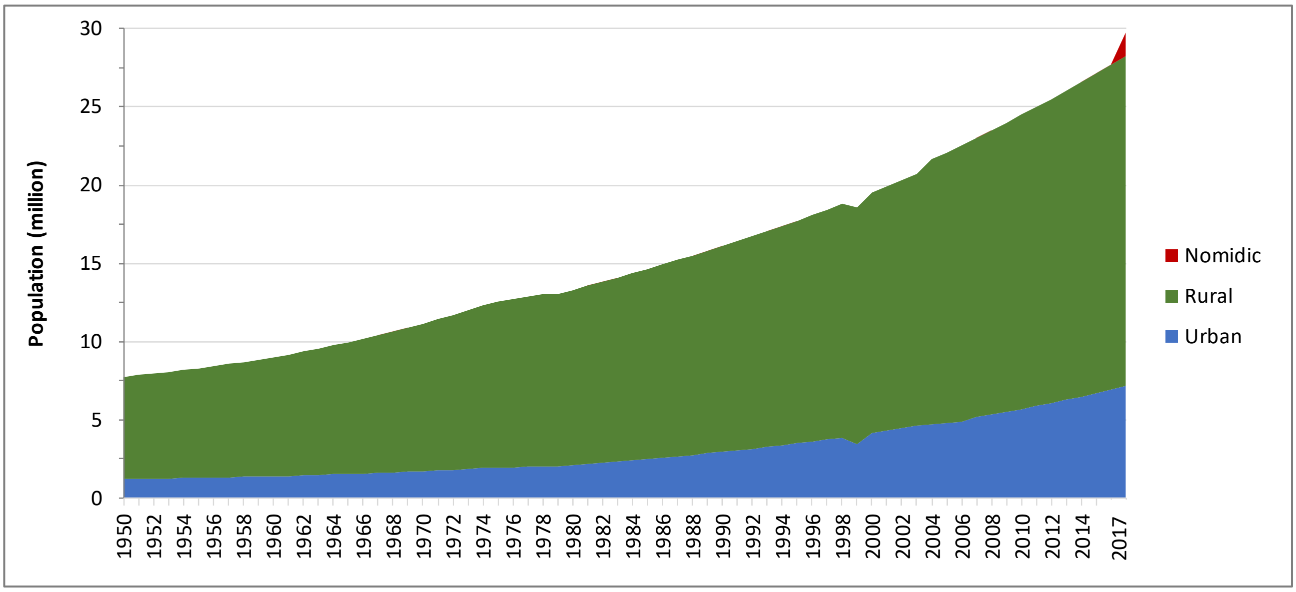

Figure 188 Population of Afghanistan 1950 - 2017

Table 298 Population of Afghanistan 1950 – 2017

Years	Total	Urban	Rural	Nomadic	Urban	Rural	Nomadic	Source
	1000 person				Share			
1950	7 752	1 196	6 556		15%	85%		UN, World Population Prospects 2017
1951	7 856	1 212	6 643		15%	85%		*interpolation*
1952	7 960	1 228	6 731		15%	85%		
1953	8 063	1 244	6 819		15%	85%		
1954	8 167	1 260	6 907		15%	85%		
1955	8 271	1 276	6 994		15%	85%		UN, World Population Prospects 2017
1956	8 416	1 299	7 117		15%	85%		*interpolation*
1957	8 561	1 321	7 240		15%	85%		
1958	8 706	1 344	7 362		15%	85%		
1959	8 851	1 366	7 485		15%	85%		

[205] UN - World Population Prospects 2019; available (21 March 2019) on https://population.un.org/wpp/Download/Standard/Population/

[206] UN - Demographic and Social Statistics; available (21 March 2019) on https://unstats.un.org/unsd/demographic-social/index.cshtml

[207] NSIA; available (21 March 2019) on http://cso.gov.af/en/page/demography-and-socile-statistics/demograph-statistics

Years	Total	Urban	Rural	Nomadic	Urban	Rural	Nomadic	Source
	1000 person				Share			
1960	8 996	1 388	7 608		15%	85%		UN, World Population Prospects 2017
1961	9 185	1 417	7 767		15%	85%		*interpolation*
1962	9 373	1 446	7 927		15%	85%		
1963	9 562	1 476	8 086		15%	85%		
1964	9 750	1 505	8 245		15%	85%		
1965	9 938	1 534	8 405		15%	85%		UN, World Population Prospects 2017
1966	10 176	1 570	8 606		15%	85%		*interpolation*
1967	10 413	1 607	8 806		15%	85%		
1968	10 651	1 644	9 007		15%	85%		
1969	10 889	1 680	9 208		15%	85%		
1970	11 126	1 717	9 409		15%	85%		UN, World Population Prospects 2017
1971	11 419	1 762	9 657		15%	85%		*interpolation*
1972	11 712	1 807	9 904		15%	85%		
1973	12 005	1 853	10 152		15%	85%		
1974	12 297	1 898	10 400		15%	85%		
1975	12 590	1 943	10 647		15%	85%		UN, World Population Prospects 2017
1976	12 733	1 965	10 768		15%	85%		*interpolation*
1977	12 876	1 987	10 889		15%	85%		
1978	13 019	2 009	11 010		15%	85%		
1979	13 051	2 014	11 037		15%	85%		UN, Demographic Statistics Database
1980	13 304	2 085	11 220		16%	84%		
1981	13 562	2 156	11 406		16%	84%		
1982	13 820	2 228	11 592		16%	84%		
1983	14 088	2 304	11 784		16%	84%		
1984	14 357	2 381	11 976		17%	83%		
1985	14 625	2 457	12 168		17%	83%		
1986	14 929	2 562	12 367		17%	83%		
1987	15 218	2 642	12 576		17%	83%		
1988	15 513	2 752	12 761		18%	82%		
1989	15 814	2 851	12 963		18%	82%		
1990	16 121	2 953	13 167		18%	82%		
1991	16 433	3 037	13 396		18%	82%		
1992	16 752	3 144	13 608		19%	81%		
1993	17 076	3 255	13 822		19%	81%		
1994	17 407	3 369	14 038		19%	81%		
1995	17 745	3 489	14 256		20%	80%		
1996	18 089	3 612	14 477		20%	80%		
1997	18 439	3 740	14 699		20%	80%		
1998	18 797	3 874	14 923		21%	79%		
1999	18 598	3 452	15 145		19%	81%		
2000	19 533	4 155	15 378		21%	79%		
2001	19 911	4 309	15 602		22%	78%		
2002	20 298	4 463	15 835		22%	78%		
2003	20 691	4 630	16 062		22%	78%		

Years	Total	Urban	Rural	Nomadic	Urban	Rural	Nomadic	Source
	1000 person				Share			
2004	21 678	4 669	17 009		22%	78%		NSIA, Settled Population by civil division (Urban and Rural)
2005	22 098	4 759	17 339		22%	78%		
2006	22 576	4 862	17 714		22%	78%		
2007	23 039	5 159	17 880		22%	78%		
2008	23 511	5 330	18 181		23%	77%		
2009	23 994	5 507	18 486		23%	77%		
2010	24 486	5 690	18 795		23%	77%		
2011	24 988	5 879	19 109		24%	76%		
2012	25 500	6 074	19 426		24%	76%		
2013	26 023	6 276	19 748		24%	76%		
2014	26 557	6 484	20 073		24%	76%		
2015	27 101	6 698	20 403		25%	75%		
2016	27 657	6 920	20 738		25%	75%		
2017	29 724	7 148	21 076	1500	24%	71%	5%	

In order to estimate the annual waste generation for Afghanistan information on municipal solid waste generation rates for the urban and the rural population was collected. In the following table the data used in the inventory are presented. The data are based on studies and expert judgement by national experts from Independent Directorate of Local Governance (IDLG), Municipality of Kabul and National Protection Agency (NEPA), University of Kabul and Kabul Polytechnic University.

Table 299 Waste generation rate for Afghanistan

	Municipal Solid Waste (MSW) generation rate kg/cap/year (value in brackets: kg/cap/day)				
	Total population	Urban population	Source	Rural population	Source
1950 - 1985	71 (0.19)	123.30 (0.34)	UN-Habitat, Oct 1992; presented in Abdul Wahab Azad (2015): Solid waste management in Kabul city of Afghanistan[208]	61.7 (0.17)	50% of urban (expert judgement)
1985 - 1995		interpolation		interpolation	
1995 - 2005	89 (0.24)	146.00 (0.40)	GLAWE (2006): Solid Waste Management in Least Developed Asian Countries–A Comparative Analysis[209]	73.0 (0.20)	50% of urban; following Waste generation by income level: Low income; Source: Daniel and Perinaz (2012): What a Waste: A Global Review of Solid Waste Management. Washington, DC: World Bank.[210]

[208] Abdul Wahab Azad (2015): Solid waste management in Kabul city of Afghanistan. New Delhi. Available (25 March 2019) on https://www.academia.edu/12919045/Solid_waste_management_in_Kabul_city_of_Afghanistan

[209] Glawe, G.; Visvanathan, C. & Alamgir, M. (2006): Solid Waste Management in Least Developed Asian Countries–A Comparative Analysis. Thailand. Available (25 March 2019) on https://pdfs.semanticscholar.org/b956/2d4ec8e256dc75e14a13c9df898c8ee3682b.pdf

[210] Hoornweg, Daniel; Bhada-Tata, Perinaz. 2012. What a Waste : A Global Review of Solid Waste Management. Urban development series; knowledge papers no. 15. World Bank, Washington, DC. © World Bank. Available (25 March 2019) on https://openknowledge.worldbank.org/handle/10986/17388

	Municipal Solid Waste (MSW) generation rate kg/cap/year (value in brackets: kg/cap/day)				
	Total population	**Urban population**	**Source**	**Rural population**	**Source**
2005 - 2014		interpolation		interpolation	
2015	140 (0.38)	225.00 (0.62)	World bank (2016): What a Waste 2.0 - A Global Snapshot of Solid Waste Management to 2050[211] APPENDIX A: Waste Generation and Projections by Country or Economy	112.5 (0.31)	50% of urban (expert judgement)
2016 - 2017		Value of 2015		value of 2015	

7.1.2.5 Allocation of the Municipal Solid Waste (MSW) to various waste treatments

The allocation of the Municipal Solid Waste (MSW) to the various waste treatment techniques is done for the pillar years 1950, 1960, 1970, 1980, 1990, 2000, 2010, 2017 and is again based on expert judgement by national experts from Independent Directorate of Local Governance (IDLG), Municipality of Kabul and National Protection Agency (NEPA), University of Kabul and Kabul Polytechnic University. For the years between the pillar years interpolation was be used. In the following figures and tables an overview of the allocation of the waste from total, urban and rural population to various waste treatments is presented. For this exercise the rural and nomadic population is group as it is assumed that the waste generation rate and disposal routes are comparable.

The Step 4 - Estimation of GHG emission from the different waste treatments techniques are presented in the following chapters.

[211] Kaza, Silpa; Yao, Lisa C.; Bhada-Tata, Perinaz; Van Woerden, Frank. 2018. What a Waste 2.0 : A Global Snapshot of Solid Waste Management to 2050. Urban Development. Washington, DC: World Bank. © World Bank.
Available (25 March 2019) on https://openknowledge.worldbank.org/handle/10986/30317

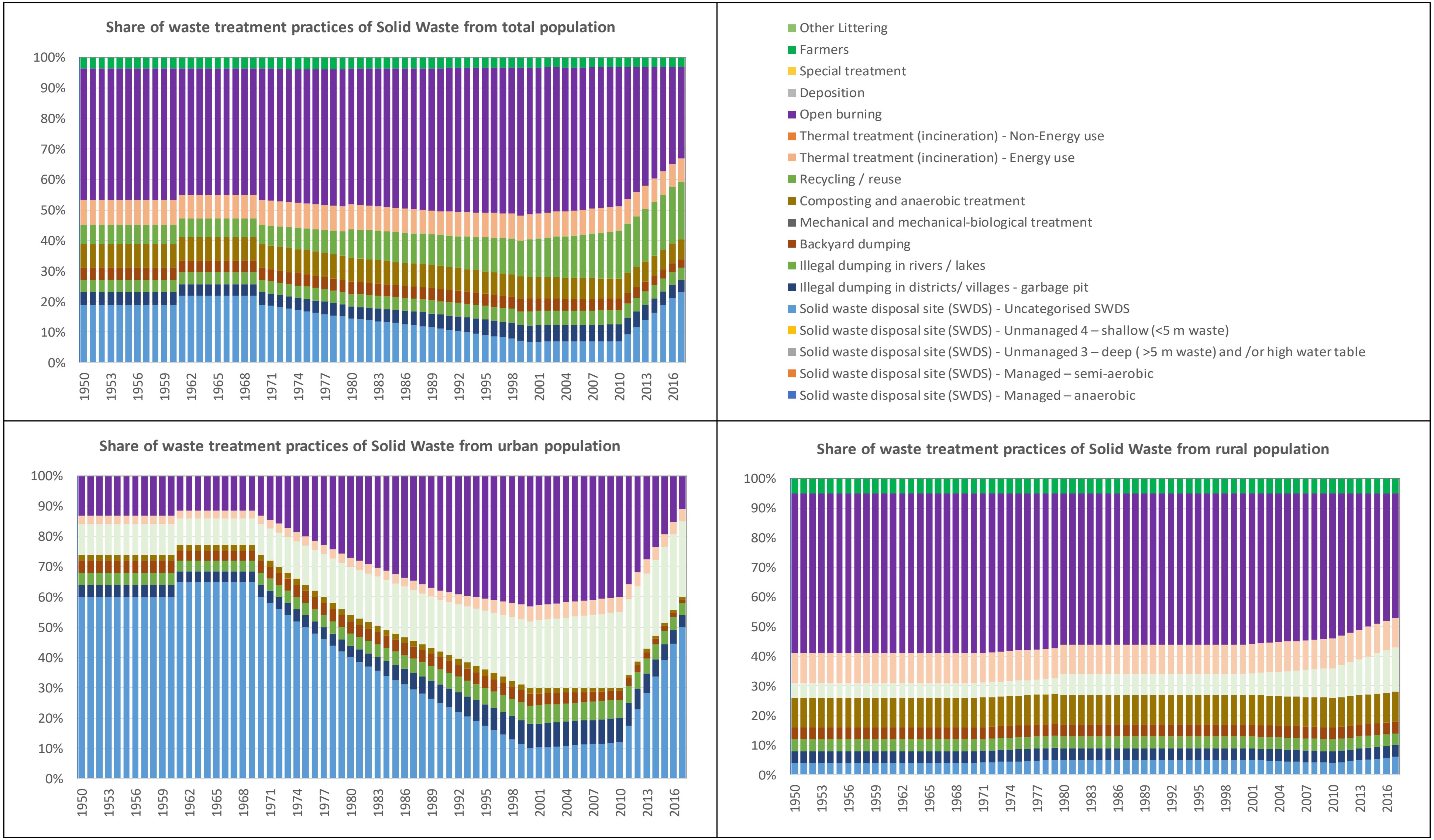

Figure 189 Share of waste treatment practices of Solid Waste from total, urban and rural population for the period 1950 - 2017

Table 300 Allocation of waste from total population to various waste treatments

		Reporting in IPCC category	1950	1960	1970	1980	1990	2000	2010	2017
			Total population							
Total Municipal Solid Waste (MSW) (tones)			551 672	640 217	791 780	948 723	1 284 150	1 729 168	2 798 815	4 148 162
% to SWDS			19%	19%	19%	14%	11%	7%	7%	23%
Municipality landfill site (Solid waste disposal site - SWDS) (directly landfilled/without pre-treatment)	**Managed – anaerobic**	**5.A**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Managed – semi-aerobic	**5.A**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Unmanaged 3 – deep (>5 m waste) and / or high-water table	**5.A**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Unmanaged 5 – shallow (<5 m waste)	**5.A**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Uncategorized SWDS	**5.A**	19.0%	19.0%	19.0%	14.5%	11.2%	6.8%	7.0%	23.1%
Illegal dumping in districts/ villages - garbage pit		**5.B**	5.0%	4.0%	4.0%	4.0%	4.6%	5.4%	5.5%	4.0%
Illegal dumping in rivers / lakes		**-**	5.0%	4.0%	4.0%	4.0%	4.3%	4.7%	4.8%	4.0%
Backyard dumping		**5.B**	5.0%	4.0%	4.0%	4.0%	4.0%	4.0%	3.6%	2.8%
Mechanical and mechanical-biological treatment		**5.B**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Composting and anaerobic treatment		**5.B**	7.9%	7.9%	7.9%	7.8%	7.5%	7.2%	6.6%	6.5%
Recycling / reuse		**-**	6.3%	6.3%	6.3%	9.4%	10.1%	12.3%	15.7%	18.9%
Thermal treatment -incineration -	**Energy use**	**1.A**	8.1%	8.1%	8.1%	8.1%	7.8%	8.2%	8.1%	7.7%
	Non-Energy use	**5.C**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Open burning		**5.C**	53.0%	43.0%	43.0%	44.5%	47.0%	48.2%	45.6%	30.0%
Deposition		**-**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Special treatment		**-**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Farmers		**-**	3.7%	3.7%	3.7%	3.6%	3.5%	3.2%	3.1%	3.1%
Other Littering		**-**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			100%	100%	100%	100%	100%	100%	100%	100%

Table 301 Allocation of waste from urban population to various waste treatments

		Reporting in IPCC category	1950	1960	1970	1980	1990	2000	2010	2017
			Urban population (share in %)							
			15%	15%	15%	16%	18%	21%	23%	24%
Total Municipal Solid Waste (MSW) Gg = 1000 t			147 508	171 183	211 708	257 021	397 662	606 564	1 055 551	1 608 350
% to SWDS			60%	60%	60%	40%	25%	10%	12%	50%
Municipality landfill site (Solid waste disposal site - SWDS) (directly landfilled/without pre-treatment)	Managed – anaerobic	5.A	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Managed – semi-aerobic	5.A	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Unmanaged 3 – deep (>5 m waste) and / or high-water table	5.A	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Unmanaged 5 – shallow (<5 m waste)	5.A	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Uncategorized SWDS	5.A	60.0%	60.0%	60.0%	40.0%	25.0%	10.0%	12.0%	50.0%
Illegal dumping in districts/ villages - garbage pit		5.B	5.0%	4.0%	4.0%	4.0%	6.0%	8.0%	8.0%	4.0%
Illegal dumping in rivers / lakes		-	5.0%	4.0%	4.0%	4.0%	5.0%	6.0%	6.0%	4.0%
Backyard dumping		5.B	5.0%	4.0%	4.0%	4.0%	4.0%	4.0%	3.0%	1.0%
mechanical and mechanical-biological treatment		5.B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
composting and anaerobic treatment		5.B	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	1.0%	1.0%
recycling / reuse		-	10.0%	10.0%	10.0%	16.0%	17.0%	22.0%	25.0%	25.0%
thermal treatment - incineration -	Energy use	1.A	3.0%	3.0%	3.0%	3.0%	3.0%	5.0%	5.0%	4.0%
	Non-Energy use	5.C	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Open burning		5.C	13.0%	13.0%	13.0%	27.0%	38.0%	43.0%	40.0%	11.0%
deposition		-	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
special treatment		-	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Farmers		-	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other Littering		-	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			100%	100%	100%	100%	100%	100%	100%	100%

Table 302 Allocation of waste from rural population to various waste treatments

		Reporting in IPCC category	1950	1960	1970	1980	1990	2000	2010	2017
			Rural population and nomadic population (share in %)							
			85%	85%	85%	84%	82%	79%	77%	76%
Total Municipal Solid Waste (MSW) Gg = 1000 t			404 164	469 034	580 071	691 702	886 488	1 122 604	1 743 264	2 539 811
% to SWDS			4%	4%	4%	5%	5%	5%	4%	6%
Municipality landfill site (Solid waste disposal site - SWDS) (directly landfilled/without pre-treatment)	Managed – anaerobic	5.A	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Managed – semi-aerobic	5.A	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Unmanaged 3 – deep (>5 m waste) and / or high water table	5.A	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Unmanaged 5 – shallow (<5 m waste)	5.A	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Uncategorised SWDS	5.A	4.0%	4.0%	4.0%	5.0%	5.0%	5.0%	4.0%	6.0%
Illegal dumping in districts/ villages - garbage pit		5.B	5.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%
Illegal dumping in rivers / lakes		-	5.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%
Backyard dumping		5.B	5.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%
mechanical and mechanical-biological treatment		5.B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
composting and anaerobic treatment		5.B	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
recycling / reuse		-	5.0%	5.0%	5.0%	7.0%	7.0%	7.0%	10.0%	15.0%
thermal treatment - incineration -	Energy used(e.g. household)	1.A	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
	Non-Energy use	5.C	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Open burning		5.C	55.0%	54.0%	54.0%	51.0%	51.0%	51.0%	49.0%	42.0%
deposition		-	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
special treatment		-	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Farmers		-	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
Other Littering		-	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			100%	100%	100%	100%	100%	100%	100%	100%

7.1.2.6 Industrial waste 1950 - 2017

As stated in the Afghanistan Statistical yearbook 2017-2018 the industrial sector contributed to GDP by 21.0 % in 2017. Most of industrial productions are produced for domestic consumption i. e. chemical fertilizer, cement, medicine, wheat flour, bread and other bakery products, meat, dry fruits process, salt, soap, toilet paper, etc.

As historical data on industrial production (amount and/or value of production, by industry type,) was not available, the historical disposal of industrial waste was estimated proportional to Gross domestic product (GDP) as recommended by 2006 IPCC Guidelines[212].

Historical data on the Gross domestic product (GDP) for Afghanistan could be obtained for the years

- 1950 – 1969: from Maddison, A. (2010), The World Economy: Historical Statistics, Development Centre Studies, OECD Publishing, Paris.[213]
- 1970 – 2003 from United Nations, Statistics Division, National Accounts Estimates of Main Aggregates[214].
- 2004 – 2017 from National Statistics and Information Authority (NSIA) of Afghanistan.

As the historical data of the GDP for 1950 – 1969 were in the unit 'million 1990 International Geary-Khamis dollars', adjustments had to be undertaken. The trend of the period 1950 – 1969 was applied to the time series and first reported value (1970) of GDP in the unit 'GDP at constant 2010 prices' provided by UN statistics division.

As the degradable organic carbon (DOC) and fossil carbon in industrial waste are the main parameters affecting the CH_4 emissions from solid waste disposal only the GDP of the subcategory 'Manufacturing' was used. For the estimation of the annual industrial waste from subcategory manufacturing the following industries were included:

- Food, beverage, & tobacco
- Textile, wearing apparel & leather
- Wood & wood prod. incl. furniture
- Paper, paper prod. printing, publishing
- Chemicals & chem petroleum, coal, rubber, plastic

As only data for the period 2002 - 2017 were available, the value of the year 2002 was applied to the period 1950 – 2001: 17 % of GPD is from Manufacturing Industries.

The industrial waste generation rate for small scale industries in kg/capita/day for 2014 is based on data from a study from Bangladesh:

> Hossain, L., Das, S. R., Talukder, S. & Hossain, M. K. (2014): Generation of Municipal Solid Waste in Commercial City of Bangladesh. Journal of Environmental Treatment Techniques 2014, Volume 2, Issue 3, Pages: 109-114.[215]

Using the GDP of Afghanistan and Bangladesh provided by UN statistic division an industrial waste generation

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[212] 2006 IPCC Guidelines, Volume 5: Waste, Chapter 3: Solid Waste Disposal - 3.2.2 Choice of activity data

[213] Available (16 March 2019) on https://doi.org/10.1787/9789264104143-en.

[214] National Accounts - Analysis of Main Aggregates (AMA); Available (13 March 2019) on https://unstats.un.org/unsd/snaama/Index

[215] Available (13 March 2019) on https://www.researchgate.net/publication/265710605_Generation_of_Municipal_Solid_Waste_in_Commercial_City_of_Bangladesh

rate for the year 1970 and 2014 were calculated.

As the industrial generation rate in Gg/$m GDP/year reflects more the trend in annual industrial production, the above-mentioned industrial waste generation rate in kg/capita/day was transferred to Gg/ $m GDP/year which is needed by the IPCC FOD model. Finally, the industrial generation rate was available for the years

- 1950-1969 - extrapolation with the coefficient of the interpolation 1970 – 2017;
- 1970 - based on ration of GDP in 2014 and 1970 in Afghanistan and Bangladesh;
- 1971 – 1988 interpolation with coefficient of the interpolation 1970 – 2017;
- 1989 - 2003: constant value of 1988 as GDP decreases significantly;
- 2004 – 2013 interpolation;
- 2014 - based on ration of GDP in 2014 and 1970 in Afghanistan and Bangladesh;
- 2015 - 2017 - extrapolation with the coefficient of the interpolation 1970 – 2017.

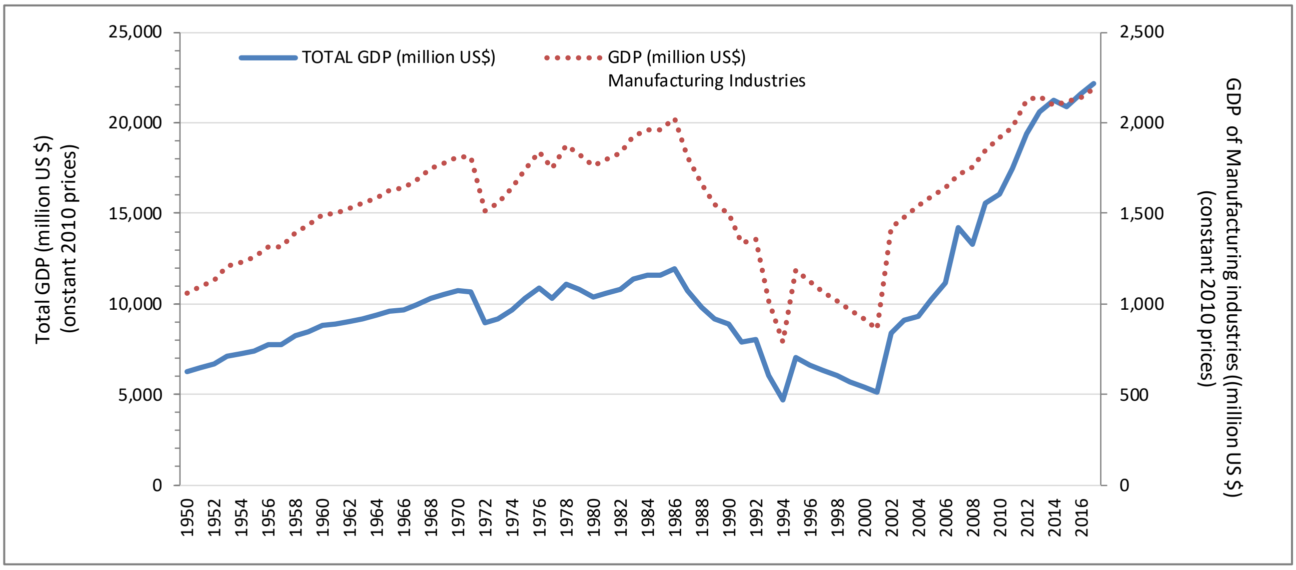


Figure 190 **Historical data on Total GDP and GDP for Manufacturing industries for the period 1950 – 2017**

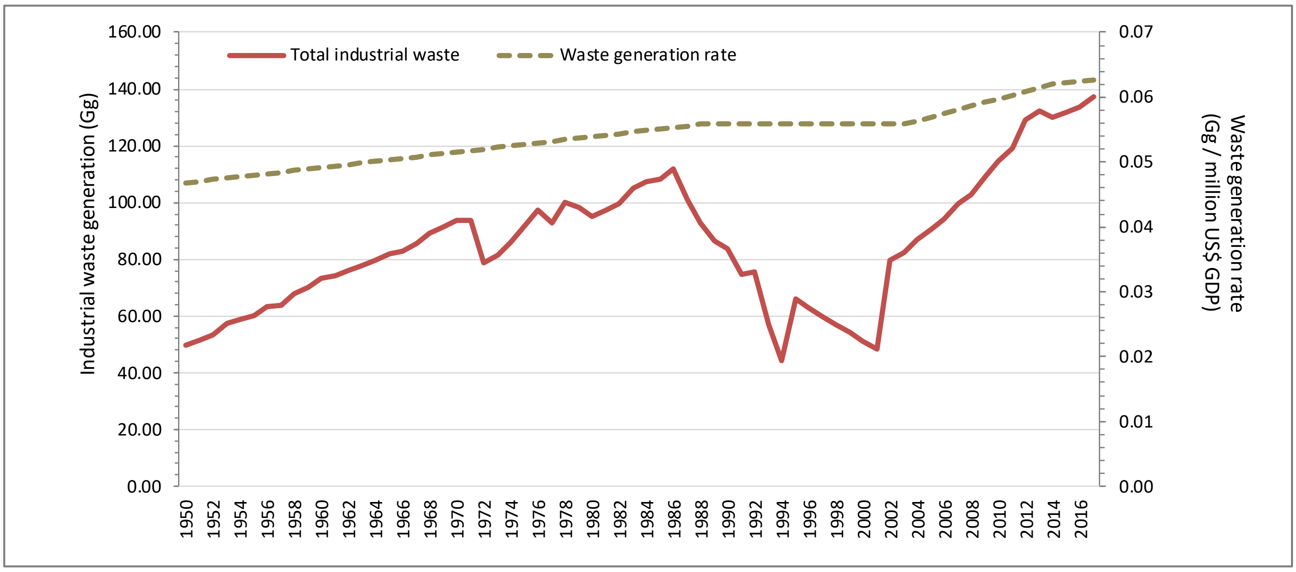


Figure 191: **Historical data on industrial waste generation rate and industrial waste for the period 1950 - 2017**

Table 303 Historical data on Total GDP and GDP for Manufacturing industries of Afghanistan 1950 – 2017

	GDP	Source	Share of sector Manufacturing Industries to GDP		Source	Industrial waste generation rate	Total industrial waste (relevant to CH_4 emission)
	million US$		million US$	Share (%)		Gg/$m GDP/year	Gg
1950	6 273	**Trend of** *'Maddison, A. (2010), The World Economy: Historical Statistics, Development Centre Studies, OECD Publishing, Paris.'* **applied to data of 1970 of** *United Nations, Statistics Division, National Accounts Estimates of Main Aggregates*	1 062	Value of 2002		*extrapolation*	49.69
1951	6 461		1 094				51.44
1952	6 687		1 132				53.51
1953	7 123		1 206				57.28
1954	7 277		1 232				58.82
1955	7 425		1 257				60.32
1956	7 775		1 316				63.47
1957	7 775		1 316				63.78
1958	8 238		1 395				67.91
1959	8 481		1 436				70.25
1960	8 797		1 489				73.23
1961	8 874		1 502				74.22
1962	9 029		1 529				75.89
1963	9 198		1 557				77.68
1964	9 379		1 588				79.59
1965	9 594		1 624				81.79
1966	9 690		1 641				83.01
1967	9 966		1 687				85.77
1968	10 336		1 750				89.37
1969	10 505		1 779				91.25
1970	10 721	United Nations, Statistics Division, National Accounts Estimates of Main Aggregates	1 815			0.0515	93.56
1971	10 691		1 810			*interpolation*	93.73
1972	8 938		1 513				78.72
1973	9 197		1 557				81.37
1974	9 698		1 642				86.20
1975	10 300		1 744				91.96
1976	10 863		1 839				97.43
1977	10 315		1 746				92.93
1978	11 079		1 876				100.26
1979	10 794		1 827				98.11
1980	10 393		1 759				94.88
1981	10 616		1 797				97.35
1982	10 832		1 834				99.77
1983	11 365		1 924				105.13
1984	11 573		1 959				107.52
1985	11 604		1 965				108.27
1986	11 951		2 023				112.00
1987	10 724		1 816				100.93
1988	9 837		1 665				92.98
1989	9 143		1 548			constant value of 1988	86.41
1990	8 857		1 500				83.72
1991	7 889		1 336				74.57

	GDP	Source	Share of sector Manufacturing Industries to GDP		Source	Industrial waste generation rate	Total industrial waste (relevant to CH_4 emission)
1992	8 016		1 357				75.77
1993	6 015		1 018				56.85
1994	4 676		792				44.20
1995	7 011		1 187				66.27
1996	6 642		1 124				62.77
1997	6 300		1 067				59.55
1998	6 014		1 018				56.84
1999	5 722		969				54.09
2000	5 407		915				51.11
2001	5 100		864				48.21
2002	8 416	UN / NSIA, Gross Domestic Product by Economic Activity in Constant Price	1 425	16.9%	UN / NSIA, Gross Domestic Product by Economic Activity in Constant Price		79.54
2003	9 108		1 478	16.2%			82.49
2004	9 321		1 539	16.5%		*interpolation*	86.78
2005	10 244		1 589	15.5%			90.52
2006	11 183		1 640	14.7%			94.33
2007	14 229		1 715	12.0%			99.58
2008	13 286		1 755	13.2%			102.90
2009	15 574		1 848	11.9%			109.39
2010	16 078		1 919	11.9%			114.67
2011	17 474		1 977	11.3%			119.29
2012	19 383		2 122	10.9%			129.21
2013	20 639		2 149	10.4%			132.08
2014	21 271		2 096	9.9%		0.062	129.97
2015	20 890		2 118	10.1%		extrapolation	131.83
2016	21 634		2 139	9.9%			133.64
2017	22 175		2 192	9.9%			137.50

7.2 Solid Waste Disposal (IPCC category 5.A)

The following section describes GHG emissions resulting from solid waste disposal on land. According to 2006 IPCC Guidelines, the solid waste disposal sites (SWDS) can be divided into five groups.

⇒ 5.A.1 Managed Waste Disposal Sites

Anaerobic managed solid waste disposal sites must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste.

Semi-aerobic managed solid waste disposal sites must have controlled placement of waste and will include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system.

⇒ 5.A.2 Unmanaged Waste Disposal Sites

Unmanaged solid waste disposal sites – deep and/or with high water table are all SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 meters and/or high-water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste.

Unmanaged shallow solid waste disposal sites are all SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 metres.

⇒ 5.A.3 Uncategorized Waste Disposal Sites

Uncategorised solid waste disposal sites are those SWDS where countries cannot categorize their landfills into above four categories of managed and unmanaged SWDS.

In most of the cities of Least Developed Countries, landfill is the most preferred method for the final disposal of solid waste. Most of these sites practice open dumping, with no regards to the requirements for a sanitary landfill. However, the government and municipalities of Afghanistan are already working to develop the sanitary landfill sites in urban areas.

The methodology used to estimate emissions from waste management activities requires country- specific knowledge on waste generation, composition and management practice. The main parameters that influence the estimation of the emissions from landfills, apart from the amount of the disposed waste, is the waste composition.

These parameters are strictly dependent on the waste management policies throughout the waste streams which start from waste generation through collection and transportation, separation for resource recovery, recycling and energy recovery and terminate at landfill sites. The improvements of quality and quantity of data is needed. However, it with the available information and expert judgement it was possible to evaluate, and compile data coming from different sources and adjust them to recommended IPCC methodology which is used for GHGs emissions estimation. Currently country specific data was used where they are available. Default values were used when country specific data were not available.

7.2.1 Source category description

GHG emissions/ removals	CO_2	CH_4	N_2O
Estimated			
5.A.1 Managed Waste Disposal Sites	NA	NO	NA
5.A.2 Unmanaged Waste Disposal Sites	NA	NO	NA
5.A.3 Uncategorized Waste Disposal Sites	NA	✓	NA
Key Category	-	LA 1990, 2017; TA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential			
LA – Level Assessment (in year); TA – Trend Assessment			

An overview of the GHG emissions from IPCC sub-category 5.A *Solid Waste Disposal* is provided in the following figure and table. The share in total GHG emissions from sector 5.A *Solid Waste Disposal* is 0.7% for the year 1990, 0.6% for the year 2005, and 0.5% for the year 2017. The share in total CH_4 emissions from sector 5.A *Solid Waste Disposal* is 1.4% for the year 199, 1.1% for the year 2005, and 1.3% for the year 2017.

In the period 1990 – 2017 the CH_4 emissions increased by 144%. In the period 2005 – 2017 the CH_4 emissions increased by 63% mainly due to increasing landfilling activities which is a result of increasing population and growing waste generation rates. Also, the reduction of illegal disposal (sites) or open burning results in increasing landfilling.

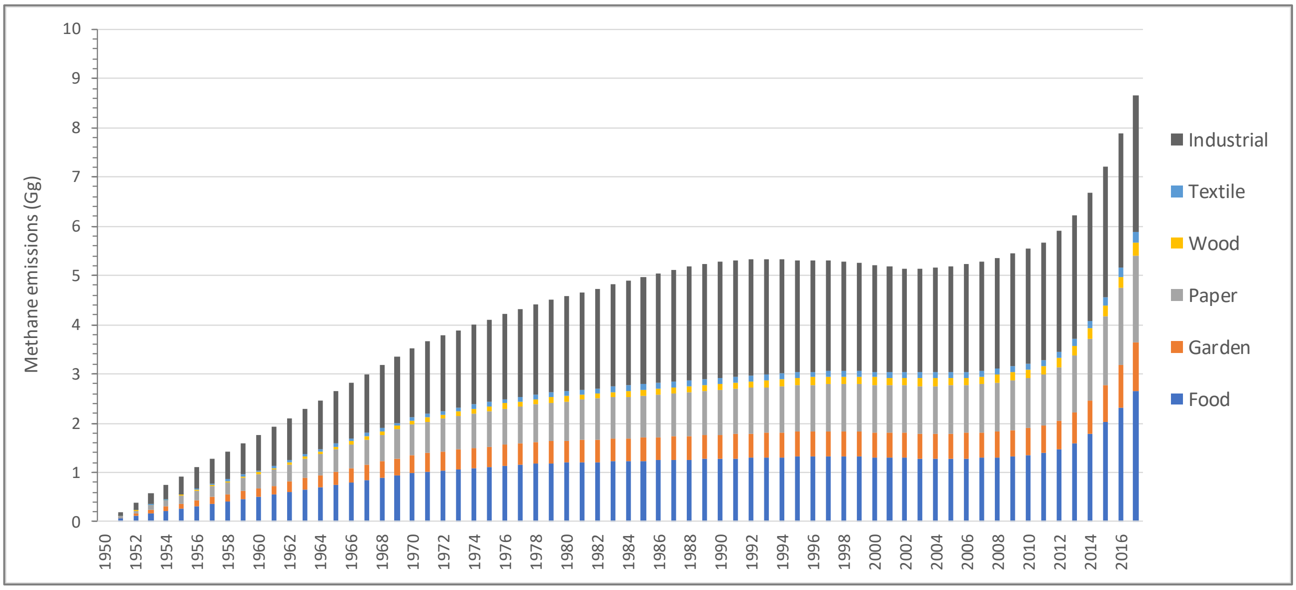


Figure 192 **CH_4 emissions from IPCC sub-category 5.A Solid Waste Disposal 1950 - 2017**

Table 304 **GHG emissions from IPCC sub-category 5.A Solid Waste Disposal 1990 - 2017**

GHG emissions	GHG	CO_2	CH_4	N_2O
	Gg $_{CO_2\ equivalent}$	Gg	Gg	Gg
1990	131.716	NA	5.269	NA
1991	132.548	NA	5.302	NA
1992	133.001	NA	5.320	NA
1993	133.481	NA	5.339	NA
1994	133.236	NA	5.329	NA

GHG emissions	GHG	CO_2	CH_4	N_2O
	Gg $_{CO_2 \text{ equivalent}}$	Gg	Gg	Gg
1995	132.520	NA	5.301	NA
1996	132.611	NA	5.304	NA
1997	132.458	NA	5.298	NA
1998	132.069	NA	5.283	NA
1999	131.463	NA	5.259	NA
2000	130.361	NA	5.214	NA
2001	129.309	NA	5.172	NA
2002	128.298	NA	5.132	NA
2003	128.578	NA	5.143	NA
2004	129.056	NA	5.162	NA
2005	129.785	NA	5.191	NA
2006	130.694	NA	5.228	NA
2007	132.000	NA	5.280	NA
2008	133.828	NA	5.353	NA
2009	136.047	NA	5.442	NA
2010	138.771	NA	5.551	NA
2011	141.952	NA	5.678	NA
2012	147.489	NA	5.900	NA
2013	155.763	NA	6.231	NA
2014	166.709	NA	6.668	NA
2015	180.363	NA	7.215	NA
2016	197.109	NA	7.884	NA
2017	216.357	NA	8.654	NA
Trend 1990 - 2017	*64%*	-	*64%*	-
Trend 2005 - 2017	*67%*	-	*67%*	-
Trend 2016 - 2017	*10%*	-	*10%*	-

Table 305 NMVOC emissions from IPCC sub-category 5.A Solid Waste Disposal 1990 - 2017

GHG emissions	NO_x	CO	NMVOC	SO_2
	Gg	Gg	Gg	Gg
1990	NA	NA	0.310	NA
1991	NA	NA	0.305	NA
1992	NA	NA	0.300	NA
1993	NA	NA	0.294	NA
1994	NA	NA	0.287	NA
1995	NA	NA	0.278	NA
1996	NA	NA	0.263	NA
1997	NA	NA	0.247	NA
1998	NA	NA	0.229	NA

GHG emissions	NO_x	CO	NMVOC	SO_2
	Gg	Gg	Gg	Gg
1999	NA	NA	0.181	NA
2000	NA	NA	0.189	NA
2001	NA	NA	0.200	NA
2002	NA	NA	0.211	NA
2003	NA	NA	0.224	NA
2004	NA	NA	0.230	NA
2005	NA	NA	0.238	NA
2006	NA	NA	0.261	NA
2007	NA	NA	0.297	NA
2008	NA	NA	0.327	NA
2009	NA	NA	0.360	NA
2010	NA	NA	0.395	NA
2011	NA	NA	0.618	NA
2012	NA	NA	0.872	NA
2013	NA	NA	1.159	NA
2014	NA	NA	1.481	NA
2015	NA	NA	1.841	NA
2016	NA	NA	2.165	NA
2017	NA	NA	2.509	NA
Trend 1990 - 2017	-	-	*74%*	-
Trend 2005 - 2017	-	-	*9%*	--
Trend 2016 - 2017	-	-	*86%*	

7.2.2 Methodological issues

7.2.2.1 Choice of methods

CH_4 Emissions from solid waste disposal on land have been calculated using the First Order Decay (FOD) method, the IPCC Tier 1 method given in the 2006 IPCC Guidelines. The choice of a *good practice* method depends on national circumstances.

- Tier 1: The estimations of the Tier 1 methods are based on the IPCC FOD method using mainly default activity data and default parameters.
- Tier 2: Tier 2 methods use the IPCC FOD method and some default parameters but require good quality country-specific activity data on current and historical waste disposal at SWDS. Historical waste disposal data for 10 years or more should be based on country-specific statistics, surveys or other similar sources. Data are needed on amounts disposed at the SWDS.

Influencing factors of CH_4 Emissions generation and relevant data required:

- Waste amounts deposited / waste generated (starting year 1950)
- Waste treatment (collection, deposition/landfilling, composting, incineration/burning, recycling)
- Management practices at landfill sites – Methane correction factor (MCF)
- Conditions at landfill sites + Composition of waste deposited
- Organic carbon in landfill sites – degradable organic carbon (DOC)
- Methane generation rate constant (k)
- Landfill gas recovery, Oxidation
- National waste management policy

For estimating the CH_4 emissions the 2006 IPCC Guidelines Tier 1 approach[216] has been applied:

EQUATION 3.1 CH_4 emission from SWDS (2006 IPCC GL, Vol. 5, Chap.3)

$$CH_4\ Emissions = \left[\sum CH_4\ generated_{x,T} - R_T\right] \times (1 - OX_T)$$

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)

Methane generation: The CH_4 generation potential of the waste that is disposed in a certain year will decrease gradually throughout the following decades. In this process, the release of CH_4 from this specific amount of waste decreases gradually. The FOD model is built on an exponential factor that describes the fraction of degradable material which each year is degraded into CH_4.

The quantity of CH_4 emitted during decomposition process is directly proportional to the fraction of degradable organic carbon (DOC), which is defined as the carbon content of different types of organic biodegradable wastes such as paper and textiles, garden and park waste, food waste, wood and straw waste. The equations for estimating the CH_4 generation are given below. As the mathematics are the same for estimating the CH_4 emissions from all waste categories/waste types/materials, no indexing referring to the different categories/waste materials/types is used in the equations below.

Equation 3.2: Decomposable DOC from waste disposal data (2006 IPCC GL, Vol. 5, Chap.3)

$$DDOCm = W \times DOC \times DOC_f \times MCF$$

Where

DDOCm	= mass of decomposable DOC deposited (Gg)
W	= mass of waste deposited (Gg)
DOC	= degradable organic carbon in the year of deposition, fraction (Gg C/Gg waste)
DOC_f	= fraction of DOC that can decompose (fraction)
MCF	= CH_4 correction factor for aerobic decomposition in the year of deposition (fraction)

[216] Source: 2006 IPCC Guidelines, Volume 5: Waste, Chapter 3: Solid Waste Disposal - 3.2.1.1 FIRST ORDER DECAY (FOD)

Although CH_4 generation potential (Lo)[2] is not used explicitly in the 2006 IPCC Guidelines, it equals the product of DDOCm, the CH_4 concentration in the gas (F) and the molecular weight ratio of CH_4 and C.

Equation 3.2: Transformation from DDOCm to L_O (2006 IPCC GL, Vol. 5, Chap.3)

$$L_o = DDOCm \times F \times \frac{16}{12}$$

Where:

Lo	= CH_4 generation potential (Gg CH_4)
DDOCm	= mass of decomposable DOC (Gg)
F	= fraction of CH_4 in generated landfill gas (volume fraction)
16/12	= molecular weight ratio CH_4/C (ratio)

FIRST ORDER DECAY BASICS

With a first order reaction, the amount of product is always proportional to the amount of reactive material. This means that the year in which the waste material was deposited in the SWDS is irrelevant to the amount of CH_4 generated each year. It is only the total mass of decomposing material currently in the site that matters.

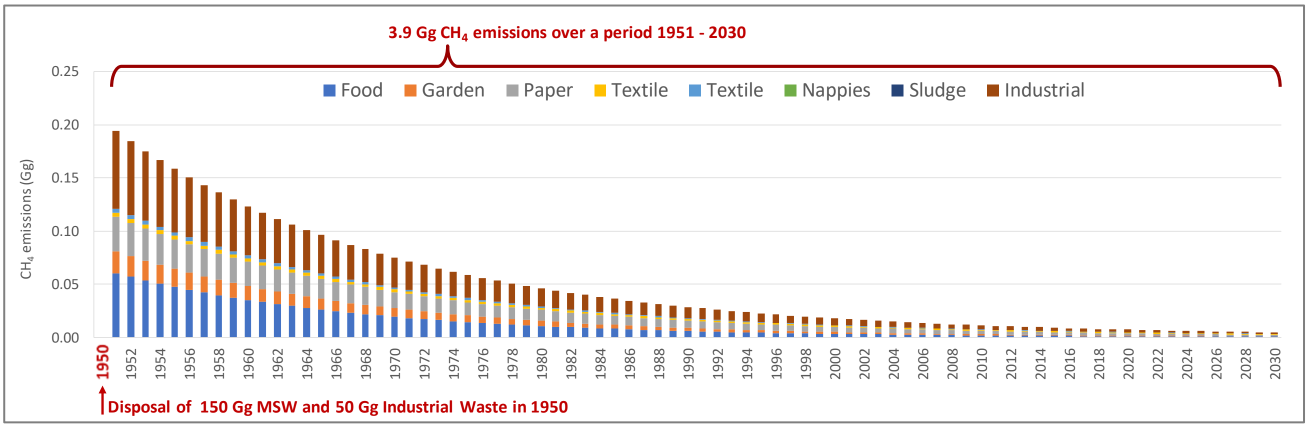


Figure 193 CH_4 emissions from IPCC sub-category 5.A Solid Waste Disposal of the disposal of waste in 1950

This also means that when the amount of decomposing material in the SWDS at the start of the year is known, every year can be regarded as year number 1 in the estimation method, and the **basic first order calculations** can be done by these two simple equations, with the decay reaction beginning on the 1st of January the year after deposition.

Equation 3.4: DDOCm accumulated in the SWDS at the end of year T (2006 IPCC GL, Vol. 5, Chap.3)

$$DDOCma_T = DDOCmd_T + \left(DDOCmd_T \times e^{-k}\right)$$

Equation 3.5: DDOCm decomposed in the SWDS at the end of year T (2006 IPCC GL, Vol. 5, Chap.3)

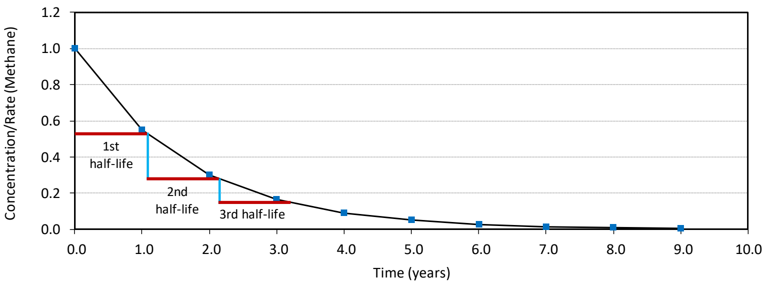
$$DDOCm\ decomp_T = DDOCma_{T-1} \times \left(1 - e^{-k}\right)$$

Where:

T	= inventory year
DDOCmaT	= DDOCm accumulated in the SWDS at the end of year T (Gg)
DDOCmaT-1	= DDOCm accumulated in the SWDS at the end of year (T-1) (Gg)
DDOCmdT	= DDOCm deposited into the SWDS in year T (Gg)

DDOCm decompT = DDOCm decomposed in the SWDS in year T (Gg)
k = reaction constant,
k = $\ln(2)/t_{1/2}$ (y-1)
$t_{1/2}$ = half-life time (y)

The half-life of a reaction, t1/2, is the amount of time needed for a reactant concentration to decrease by half compared to its initial concentration.



In a First order reactions, the graph represents the half-life is different from zero order reaction in a way that the slope continually decreases as time progresses until it reaches zero. We can also easily see that the length of half-life will be constant, independent of concentration. For example, it takes the same amount of time for the concentration to decrease from one point to another point.

Figure 194 First order reaction

CH_4 GENERATED FROM DECOMPOSABLE DDOCm

The amount of CH_4 formed from decomposable material is found by multiplying the CH_4 fraction in generated landfill gas and the CH_4 /C molecular weight ratio.

Equation 3.6: CH_4 generated from decayed DDOCm (2006 IPCC GL, Vol. 5, Chap.3)

$$\boldsymbol{CH_4\ generated_T = DDOCm\ decomp_T \times F \times \frac{16}{12}}$$

Where:

CH_4 generated$_T$ = amount of CH_4 generated from decomposable material
DDOCm decomp$_T$ = DDOCm decomposed in year T (Gg)
F = fraction of CH_4, by volume, in generated landfill gas (fraction)
16/12 = molecular weight ratio CH_4/C (ratio)

For estimating the air pollutants emissions (NOx, CO, NMVOC, SO_2) the Tier 1 approach[217] of the EMEP/EEA air pollutant emission inventory guidebook 2016 has been applied. From wastewater treatment and discharge, the air pollutants emissions NOx, CO, and SO2 do not arise.

Tier 1 approach for process emissions from solid waste disposal

$$\boldsymbol{Emissions_{pollutant} = AD \times EF_{pollutant}}$$

Where:

Emissions $_{pollutant}$ = emissions of a given pollutant (Gg pollutant)
AD = amount of waste landfilled (Gg)
Emission factor $_{pollutant}$ = default emission factor of a given pollutant (g $_{pollutant}$/Mg waste)
Pollutant = NOx, CO, NMVOC, SO_2

[217] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, 5.A Biological treatment of waste - Solid waste disposal on land, sub-chapter 3.2 Tier 1 default approach.

7.2.2.2 Choice of activity data and emission factor

As described in chapter 7.1.2 Country-specific issues above, there are no national data on amounts of municipal waste generation and disposal available for the years 1950 to 2017. Based on the national population and country specific waste generation rates for urban and rural population the total amount of waste which is disposed on land could be estimated.

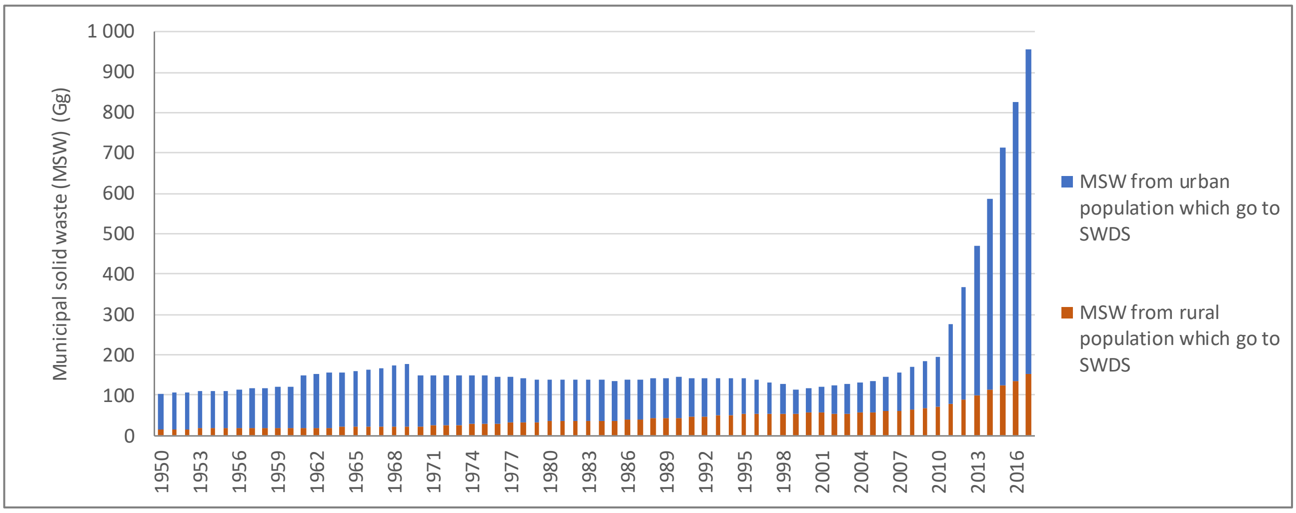


Figure 195 Municipal solid waste (MSW) landfilled on solid waste disposal sites (SWDS) from urban and rural population - 1950 - 2017

Table 306 Municipal solid waste (MSW) landfilled on solid waste disposal sites (SWDS) from total, urban and rural population - 1950 - 2017

Years	Total MSW which go to solid waste disposal sites (SWDS)		MSW from urban population which go to solid waste disposal sites (SWDS)		MSW from rural population which go to solid waste disposal sites (SWDS)	
	Gg	%	Gg	%	Gg	%
1950	104.7	19%	88.5	60%	16.2	4%
1951	106.1	19%	89.7	60%	16.4	4%
1952	107.5	19%	90.9	60%	16.6	4%
1953	108.9	19%	92.1	60%	16.8	4%
1954	110.3	19%	93.2	60%	17.0	4%
1955	111.7	19%	94.4	60%	17.2	4%
1956	113.6	19%	96.1	60%	17.6	4%
1957	115.6	19%	97.7	60%	17.9	4%
1958	117.6	19%	99.4	60%	18.2	4%
1959	119.5	19%	101.1	60%	18.5	4%
1960	121.5	19%	102.7	60%	18.8	4%
1961	148.5	23%	129.3	74%	19.2	4%
1962	151.5	23%	132.0	74%	19.5	4%
1963	154.6	23%	134.6	74%	19.9	4%
1964	157.6	23%	137.3	74%	20.3	4%
1965	160.7	23%	139.9	74%	20.7	4%
1966	164.5	23%	143.3	74%	21.2	4%
1967	168.3	23%	146.6	74%	21.7	4%
1968	172.2	23%	150.0	74%	22.2	4%

Years	Total MSW which go to solid waste disposal sites (SWDS)		MSW from urban population which go to solid waste disposal sites (SWDS)		MSW from rural population which go to solid waste disposal sites (SWDS)	
	Gg	%	Gg	%	Gg	%
1969	176.0	23%	153.3	74%	22.7	4%
1970	150.2	19%	127.0	60%	23.2	4%
1971	150.4	19%	126.0	58%	24.4	4%
1972	150.4	18%	124.8	56%	25.6	4%
1973	150.3	18%	123.3	54%	26.9	4%
1974	149.9	17%	121.7	52%	28.2	4%
1975	149.3	17%	119.8	50%	29.5	5%
1976	146.8	16%	116.3	48%	30.5	5%
1977	144.3	16%	112.7	46%	31.6	5%
1978	141.6	15%	109.0	44%	32.6	5%
1979	137.6	15%	104.3	42%	33.3	5%
1980	137.4	14%	102.8	40%	34.6	5%
1981	137.5	14%	102.4	39%	35.2	5%
1982	137.4	14%	101.7	37%	35.7	5%
1983	137.2	14%	100.9	36%	36.3	5%
1984	136.7	13%	99.8	34%	36.9	5%
1985	135.9	13%	98.4	33%	37.5	5%
1986	138.6	13%	99.7	31%	38.8	5%
1987	139.8	12%	99.6	30%	40.2	5%
1988	141.8	12%	100.3	28%	41.5	5%
1989	142.9	12%	100.0	27%	42.9	5%
1990	143.7	11%	99.4	25%	44.3	5%
1991	143.6	11%	97.7	24%	45.9	5%
1992	143.6	10%	96.3	22%	47.4	5%
1993	143.3	10%	94.4	21%	48.9	5%
1994	142.5	10%	92.0	19%	50.4	5%
1995	141.2	9%	89.1	18%	52.0	5%
1996	137.2	9%	84.4	16%	52.8	5%
1997	132.8	8%	79.2	15%	53.7	5%
1998	128.0	8%	73.5	13%	54.5	5%
1999	113.2	7%	58.0	12%	55.3	5%
2000	116.8	7%	60.7	10%	56.1	5%
2001	120.0	7%	64.2	10%	55.8	5%
2002	123.3	7%	67.8	10%	55.5	5%
2003	126.8	7%	71.6	11%	55.1	5%
2004	130.7	7%	73.6	11%	57.1	5%
2005	133.4	7%	76.4	11%	57.0	5%
2006	143.8	7%	83.8	11%	60.0	4%
2007	157.4	7%	95.2	11%	62.2	4%
2008	169.7	7%	104.9	12%	64.8	4%
2009	182.7	7%	115.4	12%	67.3	4%
2010	196.4	7%	126.7	12%	69.7	4%
2011	277.4	9%	198.2	17%	79.2	4%

Years	Total MSW which go to solid waste disposal sites (SWDS)		MSW from urban population which go to solid waste disposal sites (SWDS)		MSW from rural population which go to solid waste disposal sites (SWDS)	
	Gg	%	Gg	%	Gg	%
2012	368.9	12%	279.5	23%	89.4	5%
2013	471.7	14%	371.4	28%	100.3	5%
2014	586.6	16%	474.6	34%	112.1	5%
2015	714.5	19%	589.9	39%	124.6	5%
2016	827.2	21%	693.9	45%	133.3	6%
2017	956.6	23%	804.2	50%	152.4	6%

Waste composition is one of the main factors influencing emissions from solid waste treatment, as different waste types contain different amount of degradable organic carbon (DOC) and fossil carbon.

Waste types such as food waste, garden waste, paper and cardboard, wood, textiles, and nappies (disposable diapers) contain most of the DOC in MSW. Ash, dust, rubber and leather contain also certain amounts of non-fossil carbon, but this is hardly degradable. Some textiles, plastics (including plastics in disposable nappies), rubber and electronic waste contain the bulk part of fossil carbon in MSW. Paper (with coatings) and leather (synthetic) can also include small amounts of fossil carbon.

Table 307 Decomposition duration of different trash in the Municipal Solid Waste (MSW)

waste	Decomposition duration	waste	Decomposition duration
Vegetables	5 days –1 month	Leather shoes	25–40 years
Paper	2–5 months	Nylon fabric	30–40 years
Cotton T-shirt	6 months	Tin cans	50–100 years
Orange peels	6 months	Aluminium cans	80–100 years
Tree leaves	1 year	Glass bottles	1 million years
Wool socks	1–5 years	Styrofoam cup	500 years to forever
Plastic-coated paper milk cartons	5 years	Plastic bags	500 years to forever

Source: Science Learning Hub New Zealand [218]

For Afghanistan it was possible to collect country specific data on waste composition. The data used in the inventory are based on expert judgement by national experts from Independent Directorate of Local Governance (IDLG), Municipality of Kabul and National Protection Agency (NEPA). In the following table the IPCC default value is also provided. The country specific data on waste composition is in the range of the IPCC default. The lower value for wood is due to lack of fuel for household. The lower value for food waste is due to the socio-economic situation of Afghanistan.

The IPCC default values of Degradable organic carbon (DOC) were applied and is in the following table presented.

[218] Available (20.04.2019) on https://www.sciencelearn.org.nz/resources/1543-measuring-biodegradability

Table 308 Composition of waste going to solid waste disposal sites

	Food	Garden	Paper	Wood	Textile	Disposable nappies	Plastics, other inert	Source
Waste composition (share)								
IPCC Default	40%	0%	11%	8%	3%	0%	38%	TABLE 2.3, Vol. 5, Chapter 2, 2006 IPCC Guidelines
Country specific (CS)	33%	10%	10%	2%	2%	0%	43%	
Degradable organic carbon (DOC) (weight fraction, wet basis)								
IPCC Default	0.15	0.2	0.4	0.43	0.24	0.24	0.15	Based on TABLE 2.4, Chapter 2, and EQUATION 3.7, Chapter 3, Vol. 5, 2006 IPCC Guidelines

EQUATION 3.7 Estimates DOC using default carbon content values (2006 IPCC GL, Vol. 5, Chap.3)

$$\boldsymbol{DOC = \sum_i DOC_i \times W_i}$$

Where:

DOC = fraction of degradable organic carbon in bulk waste, Gg C/Gg waste

DOCi = fraction of degradable organic carbon in waste type i

Wi = fraction of waste type i by waste category

Table 309 Default dry matter content, DOC content, total carbon content and fossil carbon fraction of different MSW components

MSW component	Dry matter content in % of wet weight [1]	DOC content in % of wet waste		DOC content in % of dry waste		Total carbon content in % of dry weight		Fossil carbon fraction in % of total carbon	
	Default	Default	Range	Default	Range [2]	Default	Range	Default	Range
Paper/cardboard	90	40	36 - 45	44	40 - 50	46	42 - 50	1	0 - 5
Textiles [3]	80	24	20 - 40	30	25 - 50	50	25 - 50	20	0 - 50
Food waste	40	15	8 - 20	38	20 - 50	38	20 - 50	-	-
Wood	85 4	43	39 - 46	50	46 - 54	50	46 - 54	-	-
Garden and Park waste	40	20	18 - 22	49	45 - 55	49	45 - 55	0	0
Nappies	40	24	18 - 32	60	44 - 80	70	54 - 90	10	10
Rubber and Leather	84	(39) [5]	(39) [5]	(47) [5]	(47) [5]	67	67	20	20
Plastics	100	-	-	-	-	75	67 - 85	100	95 - 100
Metal [6]	100	-	-	-	-	NA	NA	NA	NA
Glass [6]	100	-	-	-	-	NA	NA	NA	NA
Other, inert waste	90	-	-	-	-	3	0 - 5	100	50 - 100

Remark: for footnotes see 2006 IPCC Guidelines

Source: Table 2.4, Vol. 5, Chapter 2, 2006 IPCC Guidelines

The Methane Correction Factor (MCF) reflects the way in which MSW is managed and the effect of management practices on CH_4 generation. MCF accounts for the fact that unmanaged SWDS produce less CH_4 from a given amount of waste than anaerobic managed SWDS. The methodology requires countries to provide data or estimates of the quantity of waste that is disposed of to each of categories of solid waste disposal sites. 2006 IPCC Guidelines provides default values for MCF (2006 IPCC, Vol.5: Waste Table 3.1, p.6.8).

Table 310 SWDS classification and methane correction factors (MCF)

Type of Site	Methane Correction Factor (MCF) Default Values	Source
Managed – anaerobic 1	1.0	TABLE 3.1, Vol. 5, Chapter 3, 2006 IPCC Guidelines
Managed – semi-aerobic 2	0.5	
Unmanaged 3 – deep (>5 m waste) and /or high-water table	0.8	
Unmanaged 4 – shallow (<5 m waste)	0.4	
Uncategorised SWDS 5	0.6	

1 **Anaerobic[219] managed solid waste disposal sites:** These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste.

2 **Semi-aerobic managed solid waste disposal sites:** These must have controlled placement of waste and will include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system.

3 **Unmanaged solid waste disposal sites – deep and/or with high water table:** All SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 meters and/or high-water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste.

4 **Unmanaged shallow solid waste disposal sites:** All SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 metres.

5 **Uncategorised solid waste disposal sites:** Only if countries cannot categorise their SWDS into above four categories of managed and unmanaged SWDS, the MCF for this category can be used.

Furthermore, the following default parameter are applied:

DOC dissimilated (DOCf)

Fraction of DOC dissimilated (DOCf) is an estimate of the fraction of carbon that is ultimately degraded and released from SWDS, and reflects the fact that some organic carbon does not degrade, or degrades very slowly, when deposited in SWDS. It is *good practice* to use a value of 0.5 (including lignin C) as the default (TABLE 3.1, Vol. 5, Chapter 3, 2006 IPCC Guidelines).

Fraction of methane (F) in developed gas

Most waste in SWDS generates a gas with approximately 50 percent CH_4. Only material including substantial amounts of fat or oil can generate gas with substantially more than 50 percent CH_4. Afghanistan is using the IPCC default value 0.5 for the fraction of CH_4 in landfill gas. (Vol. 5, Chapter 3, 2006 IPCC Guidelines, page 3.15)

Delay time

In most solid waste disposal sites, waste is deposited continuously throughout the year, usually on a daily basis. However, there is evidence that production of CH_4 does not begin immediately after deposition of the waste. Afghanistan uses the default delay of six months. (Vol. 5, Chapter 3, 2006 IPCC Guidelines, page 3.19)

[219] Anaerobic means "living, active, occurring, or existing in the absence of free oxygen", as opposed to aerobic which means "living, active, or occurring only in the presence of oxygen."

Oxidation factor (OX)

The oxidation factor (OX) reflects the amount of CH_4 from SWDS that is oxidized in the soil or other material covering the waste. (TABLE 3.2, Vol. 5, Chapter 3, 2006 IPCC Guidelines)

Methane recovery (R)

CH_4 generated at SWDS can be recovered and combusted in a flare or energy device.

In Afghanistan, no methane recovery (R) is in place.

Table 311 Recommended default methane generation rate (k) values under Tier 1

Type of Waste		Climate Zone*							
		Boreal and Temperate (MAT ≤ 20°C)				Tropical[1] (MAT > 20°C)			
		Dry (MAP/PET < 1)		Wet (MAP/PET > 1)		Dry (MAP < 1000 mm)		Moist and Wet (MAP ≥ 1000 mm)	
		Default	Range[2]	Default	Range[2]	Default	Range[2]	Default	Range[2]
Slowly degrading waste	Paper/textiles waste	**0.04**	0.03[3,5] – 0.05[3,4]	0.06	0.05 – 0.07[3,5]	0.045	0.04 – 0.06	0.07	0.06 – 0.085
	Wood/ straw waste	**0.02**	0.01[3,4] – 0.03[6,7]	0.03	0.02 – 0.04	0.025	0.02 – 0.04	0.035	0.03 – 0.05
Moderately degrading waste	Other (non – food) organic putrescible/ Garden and park waste	**0.05**	0.04 – 0.06	0.1	0.06 – 0.1[8]	0.065	0.05 – 0.08	0.17	0.15 – 0.2
Rapidly degrading waste	Food waste/Sewage sludge	**0.06**	0.05 – 0.08	0.185[4]	0.1[3,4] – 0.2[9]	0.085	0.07 – 0.1	0.4	0.17 – 0.7[10]
Bulk Waste		**0.05**	0.04 – 0.06	0.09	0.08[8] – 0.1	0.065	0.05 – 0.08	0.17	0.15[11] – 0.2

Remark: for footnotes see 2006 IPCC Guidelines

Source: Table 3.3, Vol. 5, Chapter 3, 2006 IPCC Guidelines

Table 312 Recommended default half-life (t1/2) values (YR) under Tier 1

Type of Waste		Climate Zone*							
		Boreal and Temperate (MAT ≤ 20°C)				Tropical[1] (MAT > 20°C)			
		Dry (MAP/PET < 1)		Wet (MAP/PET > 1)		Dry (MAP < 1000 mm)		Moist and Wet (MAP ≥ 1000 mm)	
		Default	Range[2]	Default	Range[2]	Default	Range[2]	Default	Range[2]
Slowly degrading waste	Paper/textiles waste	**17**	14[3,5] – 23[3,4]	12	10 – 14[3,5]	15	12 – 17	10	8 – 12
	Wood/ straw waste	**35**	23[3,4] – 69[6,7]	23	17 – 35	28	17 – 35	20	14 – 23
Moderately degrading waste	Other (non – food) organic putrescible/ Garden & park waste	**14**	12 – 17	7	6 – 9[8]	11	9 – 14	4	3 – 5
Rapidly degrading waste	Food waste/Sewage sludge	**12**	9 – 14	44	3[3,4] – 6[9]	8	6 – 10	2	1[10] – 4
Bulk Waste		**14**	12 – 17	7	6 – 9[8]	11	9 – 14	4	3 – 5[11]

Remark: for footnotes see 2006 IPCC Guidelines

Source: Table 3.4, Vol. 5, Chapter 3, 2006 IPCC Guidelines

7.2.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 5.A *Solid Waste Disposal* are presented in the following table.

Table 313 Uncertainty for IPCC sub-category 5.A Solid Waste Disposal.

Uncertainty	CH_4	**Reference** 2006 IPCC GL, Vol. 5, Chap. 3.7
Activity data (AD)	147%	Based on Table 3.5
Emission factor (EF)	98%	Based on Table 3.4 & 3.5
Combined Uncertainty (U)	177%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent with the data reported in the population statistics, GDP statistics, which were used as surrogate data.

7.2.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from three sources: national statistic, international statistics of UN and World Bank

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency

⇒ plausibility checks of dips and jumps.

7.2.5 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission (SNC) to the UNFCCC and relevant to IPCC sub-category *5.A Solid Waste Disposal*.

Table 314 Recalculations done since SNC in IPCC sub-category 5.A Solid Waste Disposal

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
5.A.	Application of 2006 IPCC Guidelines: FOD model	method	Accuracy, comparability
5.A.	Estimation of waste generation for the time series 1950 - 2017	AD	completeness

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
5.A.	Estimation of country specific waste composition	AD	Accuracy
5.A.	Application of default values of 2006 IPCC Guidelines	EF	Accuracy, comparability

7.2.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 315 Planned improvements for IPCC sub-category 5.A Solid Waste Disposal

GHG source & sink category	Planned improvement	Type of improvement		Priority
5	Investigation on waste flow: collection, disposal, recycling, incineration with energy and without energy recovery, open burning, composting, etc. • Urban population • Rural population	AD	Accuracy Transparency Comparability Completeness	High
5	Investigation on waste generation (rate) • by urban and rural population • by climate zone (see Table 312 & Table 311) • by composition	AD		High
5	Investigation on amount and waste management practices regarding clinic waste, sludge, hazardous waste, etc.	AD		High
5	Investigation on industrial waste generation and industrial waste management practices	AD		High
5.A	Investigation on waste management practices (managed, unmanaged, unspecified) (see Table 310)	AD		High
5	Investigation on illegal dumping in districts/ villages - garbage pit, illegal dumping in rivers / lakes, backyard dumping	AD		High
5.A	In-depth analysis of existing data on waste collection and disposal from municipalities for application of higher TIER methodology (TIER 2): good quality country-specific activity data on current and historical waste disposal at SWDS (data for the last 5-10 years (or more))	AD		High
all	Updating population statistics regarding nomadic population	AD	Completeness	Medium

7.3 Biological treatment of solid waste (IPCC category 5.B)

The following section describes GHG emissions resulting from biological treatment of solid waste, which originates from three different processes:

- Composting,
- anaerobic digestion of organic waste, and
- mechanical-biological (MB) treatment.

Composting and anaerobic digestion of organic waste, such as food waste, garden and park waste and sludge, is common in many countries. Advantages of the biological treatment include:

- reduced volume in the waste material,
- stabilization of the waste,
- destruction of pathogens in the waste material, and
- production of biogas for energy use.

The end products of the biological treatment can, depending on its quality, be recycled as fertilizer and soil amendment, or be disposed in Solid waste disposal sites (SWDS).

Anaerobic treatment is usually linked with methane (CH_4) recovery and combustion for energy, and thus the greenhouse gas emissions from the process should be reported in the Energy Sector.

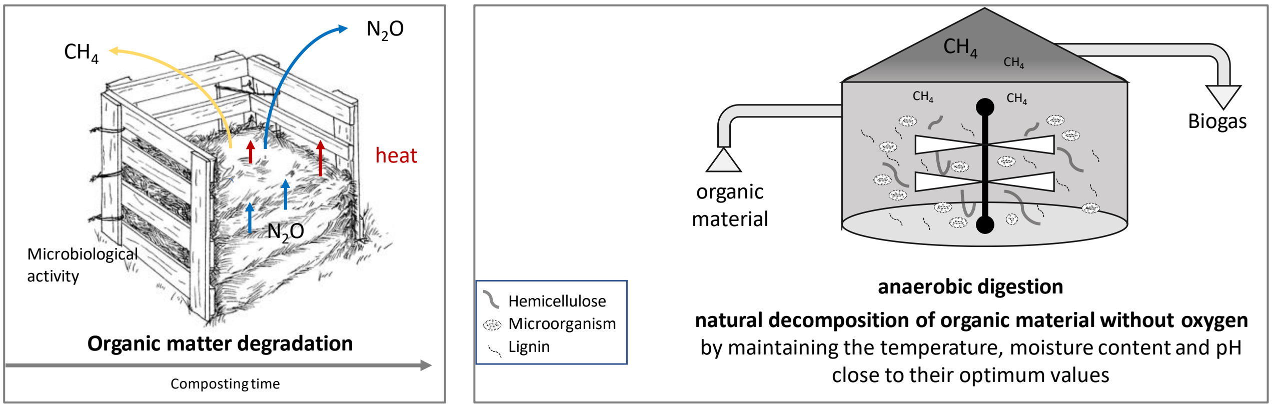


Figure 196 Scheme of composting and anaerobic digestion

Composting is the second preferred method of solid waste disposal in LDACs, mainly due to the high percentage of organic material in the waste composition. As no specific information on composting activities in Afghanistan were available, the activity needed for estimating GHG emission from composting are based on expert judgement of national experts.

Also included in IPCC sub-category 4.B *Biological treatment of solid waste* are the GHG emissions from backyard dumping and illegal dumping in districts/villages and garbage pit. As this MSW is not landfilled and not a proper decomposition takes place, it is assumed that similar/comparable processes led to GHG emissions.

7.3.1 Source category description

GHG emissions/ removals	CO_2	CH_4	N_2O
Estimated			
5.B. Biological treatment of solid waste	NA	✓	✓
Key Category	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential			
LA – Level Assessment (in year); TA – Trend Assessment			

An overview of the GHG emissions from IPCC sub-category 5.B *Biological treatment of solid waste* is provided in the following figure and table. The share in total GHG emissions from 5.B *Biological treatment of solid waste* is 0.1% for the year 1990, 0.1% for the year 2005, and 0.1% for the year 2017. The share in total CH_4 emissions from 5.B *Biological treatment of solid waste* is 0.1% for the year 1990, 0.2% for the year 2005, and 0.2% for the year 2017. The share in total N_2O emissions from 5.B *Biological treatment of solid waste* is 0.3% for the year 1990, 0.2% for the year 2005, and 0.4% for the year 2017.

In the period 1990 – 2017 the GHG emissions increased by 167%. In the period 2005 – 2017 the GHG emissions increased by 74% mainly due to increasing waste generation rate due to growing population, composting activities but also still due to backyard dumping and illegal dumping in districts/villages and garbage pit.

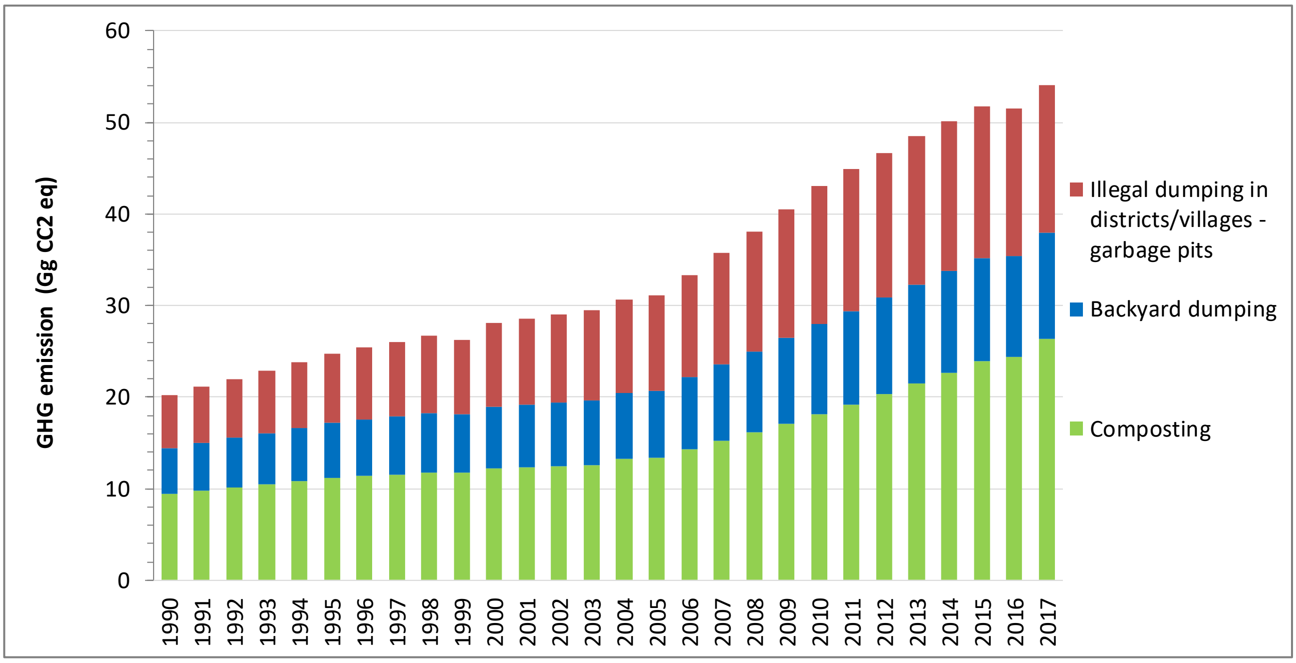


Figure 197 Emissions from IPCC sub-category 5.B Biological treatment of solid waste 1990 - 2017

Table 316 Emissions from IPCC sub-category 5.B Biological treatment of solid waste 1990 - 2017

GHG emissions	5.B Biological treatment	Composting		Backyard dumping		Illegal dumping in districts/villages & garbage pit	
	Total GHG	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O
	Gg $_{CO_2\ equivalent}$	Gg	Gg	Gg	Gg	Gg	Gg
1990	20.27	0.22	0.01	0.14	0.01	0.12	0.01
1991	21.10	0.23	0.01	0.14	0.01	0.12	0.01
1992	21.97	0.24	0.01	0.15	0.01	0.13	0.01
1993	22.88	0.24	0.01	0.16	0.01	0.13	0.01
1994	23.81	0.25	0.02	0.17	0.01	0.14	0.01
1995	24.79	0.26	0.02	0.18	0.01	0.14	0.01
1996	25.40	0.26	0.02	0.18	0.01	0.14	0.01
1997	26.04	0.27	0.02	0.19	0.01	0.15	0.01
1998	26.69	0.27	0.02	0.20	0.01	0.15	0.01
1999	26.26	0.28	0.02	0.19	0.01	0.15	0.01
2000	28.06	0.28	0.02	0.21	0.01	0.16	0.01
2001	28.53	0.29	0.02	0.22	0.01	0.16	0.01
2002	29.01	0.29	0.02	0.22	0.01	0.16	0.01
2003	29.49	0.29	0.02	0.23	0.01	0.16	0.01
2004	30.65	0.31	0.02	0.24	0.01	0.17	0.01
2005	31.11	0.31	0.02	0.24	0.01	0.17	0.01
2006	33.35	0.33	0.02	0.26	0.02	0.18	0.01
2007	35.74	0.35	0.02	0.28	0.02	0.19	0.01
2008	38.11	0.38	0.02	0.31	0.02	0.21	0.01
2009	40.55	0.40	0.02	0.33	0.02	0.22	0.01
2010	43.06	0.42	0.03	0.35	0.02	0.23	0.01
2011	44.90	0.45	0.03	0.36	0.02	0.24	0.01
2012	46.70	0.47	0.03	0.37	0.02	0.25	0.01
2013	48.45	0.50	0.03	0.38	0.02	0.25	0.02
2014	50.14	0.53	0.03	0.38	0.02	0.26	0.02
2015	51.76	0.56	0.03	0.39	0.02	0.26	0.02
2016	51.49	0.57	0.03	0.38	0.02	0.26	0.02
2017	54.13	0.62	0.04	0.38	0.02	0.27	0.02
Trend 1990 - 2017	*167%*	*180%*	*180%*	*180%*	*180%*	*129%*	*129%*
Trend 2005 - 2017	*74%*	*97%*	*97%*	*56%*	*56%*	*57%*	*57%*
Trend 2016 - 2017	*5.1%*	*9%*	*9%*	*1%*	*1%*	*4%*	*4%*

7.3.2 Methodological issues

7.3.2.1 Choice of methods

For estimating the CH_4 emissions the 2006 IPCC Guidelines Tier 1 approach[220] has been applied. CH_4 emissions from incineration and open burning of waste are a result of incomplete combustion. Important factors affecting the emissions are temperature, residence time, and air ratio (i.e., air volume in relation to the waste amount). The CH_4 emissions are particularly relevant for open burning, where a large fraction of carbon in the waste is not oxidized. The conditions can vary much, as waste is a very heterogeneous and a low-quality fuel with variations in its calorific value.

EQUATION 4.1 CH_4 Emissions from biological treatment (2006 IPCC GL, Vol. 5, Chap.4)

$$CH_4\ emissions = \sum_i (M_i \times EF_i) \times 10^{-3} - R$$

Where:

CH_4 emissions	= CH_4 emissions in inventory year (Gg)
M_i	= mass of organic waste treated by biological treatment type i (Gg)
EFj	= CH_4 emission factor (g CH_4/kg of waste treated)
i	= composting or anaerobic digestion
R	= total amount of CH_4 recovered in inventory year (Gg CH_4)

For estimating the N_2O emissions the 2006 IPCC Guidelines Tier 1 approach[220] has been applied.

EQUATION 4.2 N_2O Emissions from biological treatment (2006 IPCC GL, Vol. 5, Chap.4)

$$N_2O\ emissions = \sum_i (M_i \times EF_i) \times 10^{-3}$$

Where:

N_2O emissions	= N_2O emissions in inventory year (Gg)
M_i	= fraction of waste type/material of component j in the MSW (as wet weight open burned)
EF_i	= aggregate CH_4 emission factor (g N_2O/Gg of waste)
i	= category or type of waste open-burned, specified as follows:

From composting activities, the air pollutants emissions NOx, CO, NMVOC, SO_2 do not arise.

7.3.2.2 Choice of activity data

As described in chapter 7.1.2 Country-specific issues above, there are no national data available for the years 1990 to 2017 on amounts of municipal waste generation, composting and backyard dumping and certainly not in regards to illegal dumping. Based on the national population and country specific waste generation rates for urban and rural population the total amount of (mainly organic) waste which is composed and disposed by backyard dumping and illegal dumping in districts/villages and garbage pits.

[220] Source: 2006 IPCC Guidelines, Volume 5: Waste, Chapter 4: Chapter 4: Biological Treatment of Solid Waste - 4.1.1 Choice of method

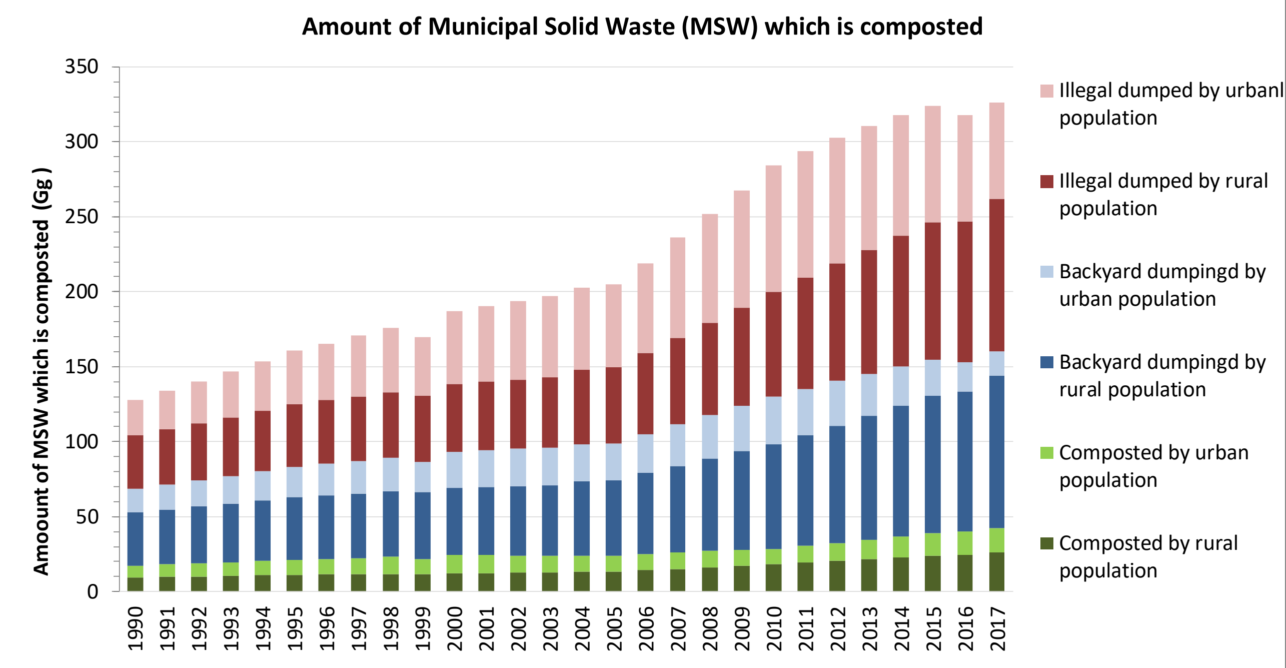


Figure 198 Amount of waste biological treated (composting) from urban and rural population

Table 317 Amount of waste biological treated (composting) from total, urban and rural population

	5.B Biological treatment	Composting		Backyard dumping		Illegal dumping in districts/villages & garbage pit	
		Rural population	Urban population	Rural population	Urban population	Rural population	Urban population
	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	207	89	8	35	16	35	24
1991	216	92	8	37	17	37	26
1992	225	95	9	38	18	38	28
1993	234	98	9	39	18	39	30
1994	244	101	10	40	19	40	33
1995	254	104	10	42	20	42	36
1996	260	106	11	42	21	42	38
1997	266	107	11	43	22	43	40
1998	273	109	11	44	23	44	43
1999	269	111	10	44	20	44	39
2000	287	112	12	45	24	45	49
2001	292	114	12	46	25	46	50
2002	297	116	12	46	25	46	52
2003	302	117	11	47	25	47	54
2004	313	124	11	50	25	50	55
2005	318	127	10	51	24	51	56
2006	341	136	10	55	25	55	60
2007	366	145	11	58	28	58	67
2008	390	154	11	62	29	62	72

	5.B Biological treatment	Composting		Backyard dumping		Illegal dumping in districts/villages & garbage pit	
		Rural population	Urban population	Rural population	Urban population	Rural population	Urban population
	Gg	Gg	Gg	Gg	Gg	Gg	Gg
2009	415	164	11	66	30	66	78
2010	440	174	11	70	32	70	84
2011	459	185	11	74	31	74	84
2012	478	196	12	78	30	78	84
2013	496	207	13	83	28	83	83
2014	513	218	14	87	26	87	80
2015	529	230	15	92	24	92	78
2016	527	233	16	93	20	93	71
2017	554	254	16	102	16	102	64
Trend 1990 - 2017	*167%*	*187%*	*102%*	*187%*	*1%*	*187%*	*170%*
Trend 2005 - 2017	*74%*	*101%*	*54%*	*101%*	*-34%*	*101%*	*16%*
Trend 2016 - 2017	*5%*	*9%*	*3%*	*9%*	*-20%*	*9%*	*-10%*

<u>Methane recovery (R)</u>

CH_4 generated at composting facilities can be recovered and combusted in a flare or energy device. In Afghanistan, no methane recovery (R) is in place.

<u>Mechanical-biological (MB) treatment</u>

In Afghanistan, no Mechanical-biological (MB) treatment takes place.

7.3.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 318 GHG Emission factor TIER 1 for IPCC sub-category 5.b Biological treatment of waste

Type of biological treatment	CH_4 Emission Factors (g CH_4/kg waste treated)		N_2O Emission Factors (g N_2O/kg waste treated)		Remarks	Source
	EF on a wet weight basis	type	EF on a wet weight basis	type		
Composting	4	D	0.24	D	Assumptions on the waste treated: 25-50% DOC in dry matter, 2% N in dry matter, moisture content 60%.	TABLE 4.1; Chap. 4, Vol. 5, 2006 IPCC GL, p 4.6

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

7.3.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 5.B *Biological treatment* are presented in the following table.

Table 319 Uncertainty for IPCC sub-category 5.B Biological treatment of solid waste.

Uncertainty	CH_4	N_2O	Reference 2006 IPCC GL, Vol. 5, Chap. 3.7
Activity data (AD)	147%	147%	Based on Table 3.5
Emission factor (EF)	50%	50%	Based on Table 3.4 & 3.5
Combined Uncertainty (U)	155%	155%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent with the data reported in the population statistics, which were used as surrogate data.

7.3.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and international statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency (plausibility checks of dips and jumps).

7.3.5 Source-specific recalculations

In INC and SNC the IPCC sub-category *5.B Biological treatment of solid waste* was not estimated. Therefore, there are no revisions.

7.3.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 320 Planned improvements for IPCC sub-category 5.B Biological treatment of solid waste.

GHG source & sink category	Planned improvement	Type of improvement		Priority
5	Investigation on waste flow: collection, disposal, recycling, incineration with energy and without energy recovery, open burning, composting, etc. (see **Error! Reference source not found.**) • Urban population • Rural population	AD	Accuracy Transparency Comparability Completeness	High
5	Investigation on waste generation (rate) • by urban and rural population • by climate zone (see Table 312 & Table 311) • by composition	AD		High
5.A	Investigation on waste management practices (managed, unmanaged, unspecified) (see Table 310)	AD		High
5	Investigation on illegal dumping in districts/ villages - garbage pit, illegal dumping in rivers / lakes, backyard dumping	AD		High
5.B	Investigation on composting activities especially in the rural area and the use of compost in agriculture	AD		High
5.B	Literature study on GHG emissions from (small-scale) illegal dumping and backyard dumping	EF		Medium

Kabul City MSW Dumpsite ©UNEP

7.4 Incineration and Open Burning of Waste (IPCC category 5.C)

The following section describes GHG emissions resulting from waste incineration and open burning of waste, which originates from:

⇒ 5.C.1 Waste Incineration

⇒ 5.C.2 Open Burning of Waste

Emissions from waste incineration without energy recovery are reported in the Waste Sector, while emissions from incineration with energy recovery are reported in the Energy Sector, both with a distinction between fossil and biogenic CO_2 emissions.

Open burning of waste can be defined as the combustion of unwanted combustible materials such as paper, wood, plastics, textiles, rubber, waste oils and other debris in nature (open-air) or in open dumps, where smoke and other emissions are released directly into the air without passing through a chimney or stack. Open burning of municipal solid waste (MSW) is not well described and an underestimated source of air pollution in developing countries due to lack of information and country specific data:

- MSW generation rates
- fraction of waste, which is combustible,
- fraction of population burning waste outside their houses and fraction of MSW burned at dump sites.

According to the 2006 IPCC Guidelines waste incineration and open burning of waste produces emissions of CO_2, CH_4 and N_2O.

According to EMEP/EEA air pollutant emission inventory guidebook 2016 relevant non-GHG from waste incineration and open burning of waste are NOx, CO, NMVOC, and SO_2 but also Particulate Matter (Dust)(TSP, PM_{10}, $PM_{2,5}$, heavy metals and persistent organic pollutants (POPs). The emissions of NOx, CO, NMVOC, and SO_2 have to be reported together with the GHG.

GHG and non-GHG Emissions from 5.C.1 Waste incineration were not estimated as in Afghanistan no information about waste incinerator (with and without energy recovery) were available.

7.4.1 Source category description

GHG emissions/ removals	CO_2	CH_4	N_2O
Estimated			
5.C.1 Waste incineration			
Municipal Solid waste	NO	NO	NO
Industrial Waste	NE	NE	NE
Sewage Sludge	NO	NO	NO
Clinical Waste	NE	NE	NE
Hazardous Waste	NE	NE	NE
5.C.2 Open Burning of Waste			
Municipal Solid waste	✓	✓	✓
Industrial Waste	NE	NE	NE
Sewage Sludge	NE	NE	NE
Clinical Waste	NE	NE	NE
Hazardous Waste	NE	NE	NE

GHG emissions/ removals	CO_2	CH_4	N_2O
Key Category			-
5.C.1 Waste incineration	-	-	-
5.C.2 Open Burning of Waste	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential			
LA – Level Assessment (in year); TA – Trend Assessment			

An overview of the GHG emission from burning of waste in IPCC sub-category 5.C Incineration and Open Burning of Waste is provided in the following figure and table. The share in total GHG emissions from sector 5.C is 0.1% for year 1990, 2005, and 2017 respectively.

In the period 1990 – 2017 the GHG emissions increased by 106%. In the period 2005 – 2017 the GHG emissions increased by 35% mainly due to

- Increasing population;
- Increasing waste generation rate;
- Increasing needs of getting rid of the solid waste and at the same time missing waste management practice.

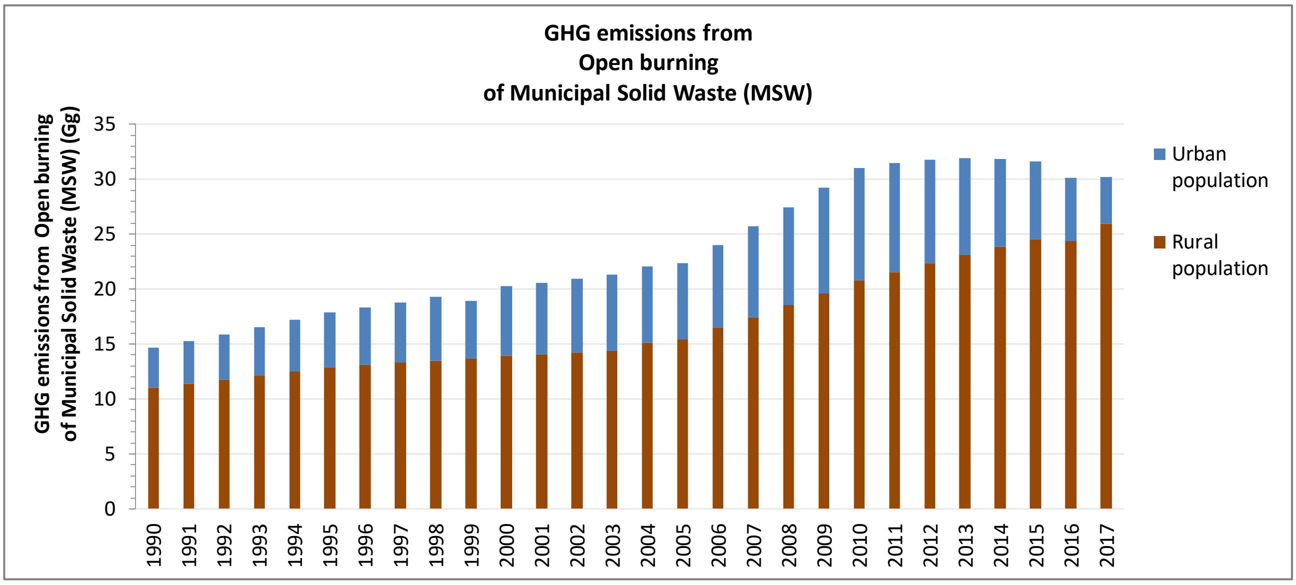


Figure 199 GHG Emissions from IPCC sub-category 5.C.2 Open Burning of Waste 1990 - 2017

Table 321 Emissions from IPCC sub-category 5.C.2 Open Burning of Waste 1990 - 2017

	Emission from Open Burning of Waste from									
	Total GHG	Total population			Rural population			Urban population		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
	Gg $_{CO_2\ equivalent}$	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	14.66	3.03	0.04	0.03	2.27	0.03	0.03	0.76	0.01	0.01
1991	15.26	3.15	0.04	0.04	2.35	0.03	0.03	0.80	0.01	0.01
1992	15.89	3.28	0.04	0.04	2.43	0.03	0.03	0.86	0.01	0.01
1993	16.54	3.42	0.04	0.04	2.50	0.03	0.03	0.91	0.01	0.01

	Emission from Open Burning of Waste from									
	Total GHG	Total population			Rural population			Urban population		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
	Gg CO_2 equivalent	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1994	17.21	3.56	0.04	0.04	2.58	0.03	0.03	0.97	0.01	0.01
1995	17.91	3.70	0.04	0.04	2.67	0.03	0.03	1.04	0.01	0.01
1996	18.35	3.79	0.05	0.04	2.71	0.03	0.03	1.09	0.01	0.01
1997	18.81	3.89	0.05	0.04	2.75	0.03	0.03	1.14	0.01	0.01
1998	19.28	3.98	0.05	0.04	2.79	0.03	0.03	1.19	0.01	0.01
1999	18.91	3.91	0.05	0.04	2.83	0.03	0.03	1.08	0.01	0.01
2000	20.25	4.19	0.05	0.05	2.88	0.03	0.03	1.31	0.02	0.01
2001	20.59	4.26	0.05	0.05	2.91	0.03	0.03	1.35	0.02	0.02
2002	20.93	4.33	0.05	0.05	2.94	0.04	0.03	1.39	0.02	0.02
2003	21.28	4.40	0.05	0.05	2.97	0.04	0.03	1.43	0.02	0.02
2004	22.07	4.56	0.05	0.05	3.13	0.04	0.03	1.43	0.02	0.02
2005	22.39	4.63	0.06	0.05	3.18	0.04	0.04	1.45	0.02	0.02
2006	23.99	4.96	0.06	0.06	3.41	0.04	0.04	1.55	0.02	0.02
2007	25.73	5.32	0.06	0.06	3.60	0.04	0.04	1.72	0.02	0.02
2008	27.45	5.67	0.07	0.06	3.83	0.05	0.04	1.84	0.02	0.02
2009	29.21	6.04	0.07	0.07	4.06	0.05	0.05	1.98	0.02	0.02
2010	31.02	6.41	0.08	0.07	4.29	0.05	0.05	2.12	0.03	0.02
2011	31.46	6.50	0.08	0.07	4.46	0.05	0.05	2.05	0.02	0.02
2012	31.76	6.56	0.08	0.07	4.62	0.06	0.05	1.95	0.02	0.02
2013	31.89	6.59	0.08	0.07	4.77	0.06	0.05	1.82	0.02	0.02
2014	31.85	6.58	0.08	0.07	4.93	0.06	0.05	1.66	0.02	0.02
2015	31.61	6.53	0.08	0.07	5.07	0.06	0.06	1.46	0.02	0.02
2016	30.11	6.22	0.07	0.07	5.04	0.06	0.06	1.18	0.01	0.01
2017	30.23	6.25	0.07	0.07	5.36	0.06	0.06	0.89	0.01	0.01
Trend										
1990 - 2017	*106%*	*106%*	*106%*	*106%*	*136%*	*136%*	*136%*	*17%*	*17%*	*17%*
2005 - 2017	*35%*	*35%*	*35%*	*35%*	*69%*	*69%*	*69%*	*-39%*	*-39%*	*-39%*
2016 - 2017	*0.4%*	*0.4%*	*0.4%*	*0.4%*	*6%*	*6%*	*6%*	*-25%*	*-25%*	*-25%*

7.4.2 Methodological issues

7.4.2.1 Choice of methods

For estimating the CO_2 emissions, the 2006 IPCC Guidelines Tier 1 approach[221] has been applied.

EQUATION 5.1 CO_2 Emission estimate based on the total amount of waste combusted (2006 IPCC Guidelines, Volume 5: Waste, Chap. 5)

$$\boldsymbol{CO_2\ emissions = M \sum_i (SW_i \times dm_i \times CF_i \times FCF_i \times OF_i) \times \frac{44}{12}}$$

Where:

CH_4 emissions	= CH_4 emissions in inventory year (Gg)	
WF_i	= fraction of waste type of component j in the MSW (as wet weight open burned)	see Table 323
dm_i	= dry matter content in the waste (wet weight) open-burned (fraction)	see Table 324
CF_i	= fraction of carbon in the dry matter (total carbon content) (fraction)	see Table 324
FCF_i	= fraction of fossil carbon in the total carbon, (fraction)	see Table 324
OF_i	= oxidation factor (fraction)	
44/12	= conversion factor from C to CO_2	
i	= type of waste open-burned specified as follows:	

- ISW: industrial solid waste ⇒ not estimated
- HW: hazardous waste ⇒ not estimated
- CW: clinical waste ⇒ not estimated
- SS: sewage sludge ⇒ not estimated

For Municipal Solid waste (MSW), it is *good practice* to calculate the CO_2 emissions on the basis of waste types/material (such as paper, wood, plastics) in the waste open-burned.

EQUATION 5.2 CO_2 Emission estimate based on the total amount of waste combusted (2006 IPCC GL, Vol. 5: Waste, Chap. 5)

$$\boldsymbol{CO_2\ emissions = MSW \times \sum_j (WF_j \times dm_j \times CF_j \times FCF_j \times OF_j) \times \frac{44}{12}}$$

Where:

CO_2 Emissions	= CO_2 emissions in inventory year (Gg)
MSW	= total amount of municipal solid waste as wet weight open-burned (Gg)
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 waste (wet weight) open-burned (fraction)
CFj	= fraction of carbon in the dry matter (total carbon content) (fraction)
FCF_j	= fraction of fossil carbon in the total carbon, (fraction)
OF_j	= oxidation factor (fraction)
44/12	= conversion factor from C to CO_2
with:	$\sum_j WF_j = 1$
j	= component of the MSW open-burned such as paper/cardboard, textiles, food waste, wood, garden & park waste, disposable nappies, rubber and leather, plastics, metal, glass, other inert waste.

[221] Source: 2006 IPCC Guidelines, Volume 5: Waste, Chapter 5: Incineration and Open Burning of Waste - 5.2.2 Choice of method for estimating CO_2 emissions

For estimating the CH_4 emissions the 2006 IPCC Guidelines Tier 1 approach[222] has been applied. CH_4 emissions from incineration and open burning of waste are a result of incomplete combustion. Important factors affecting the emissions are temperature, residence time, and air ratio (i.e., air volume in relation to the waste amount). The CH_4 emissions are particularly relevant for open burning, where a large fraction of carbon in the waste is not oxidized. The conditions can vary much, as waste is a very heterogeneous and a low quality fuel with variations in its calorific value.

EQUATION 5.4 CH_4 Emission estimate based on the total amount of waste combusted (2006 IPCC GL, Vol. 5: Waste, Chap. 5)

$$CH_4\ emissions = \sum_i (IW_i \times EF_i) \times 10^{-6}$$

Where:

CH_4 emissions = CH_4 emissions in inventory year (Gg)
MSW = total amount of municipal solid waste as wet weight open-burned (Gg)
WF_i = fraction of waste type/material of component j in the MSW (as wet weight open burned)
EFj = aggregate CH_4 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 ⇒ estimated
ISW: industrial solid waste ⇒ not estimated
HW: hazardous waste ⇒ not estimated
CW: clinical waste ⇒ not estimated
SS: sewage sludge ⇒ not estimated

For estimating the Nitrous oxide (N_2O) emissions the 2006 IPCC Guidelines Tier 1 approach[223] has been applied. N_2O is emitted in combustion processes at relatively low combustion temperatures between 500 and 950 °C.

EQUATION 5.5 N_2O emission estimate based on the total amount of waste combusted (2006 IPCC GL, Vol. 5: Waste, Chap. 5)

$$N_2O\ emissions = \sum_i (IW_i \times EF_i) \times 10^{-6}$$

Where:

N_2O emissions = N_2O emissions in inventory year (Gg)
IW_i = fraction of waste type/material of component j in the MSW (as wet weight open burned)
EF_i = aggregate N_2O emission factor (kg N_2O/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 ⇒ estimated
ISW: industrial solid waste ⇒ not estimated
HW: hazardous waste ⇒ not estimated
CW: clinical waste ⇒ not estimated
SS: sewage sludge ⇒ not estimated

[222] 2006 IPCC Guidelines, Volume 5: Waste, Chapter 5: Incineration and Open Burning of Waste - 5.2.2 Choice of method for estimating CH_4 emissions
[223] 2006 IPCC Guidelines, Volume 5: Waste, Chapter 5: Incineration and Open Burning of Waste - 5.2.2 Choice of method for estimating N_2O emissions

For estimating the air pollutants emissions (NOx, CO, NMVOC, SO_2) the Tier 1 approach[224] of the EMEP/EEA air pollutant emission inventory guidebook 2016 has been applied:

Equation 2.1: Air pollutant emissions from combustion

$$Emissions_{pollutant} = AD \times Emission\ Factor_{pollutant}$$

Where:

Emissions $_{pollutant}$	= emissions of a given pollutant by type of fuel (kg pollutant)
Activity data	= amount of waste open-burned (Gg)
Emission factor $_{pollutant}$	= default emission factor of a given pollutant by type of fuel (kg $_{pollutant}$/Mg waste)
Pollutant	= NOx, CO, NMVOC, SO_2

7.4.2.2 Choice of activity data

As described in chapter 7.1.2 Country-specific issues above, there are no national data on amounts of municipal waste generation and open burned available for the years 1990 to 2017. Based on the national population and country specific waste generation rates for urban and rural population the total amount of waste which was open burned could be estimated.

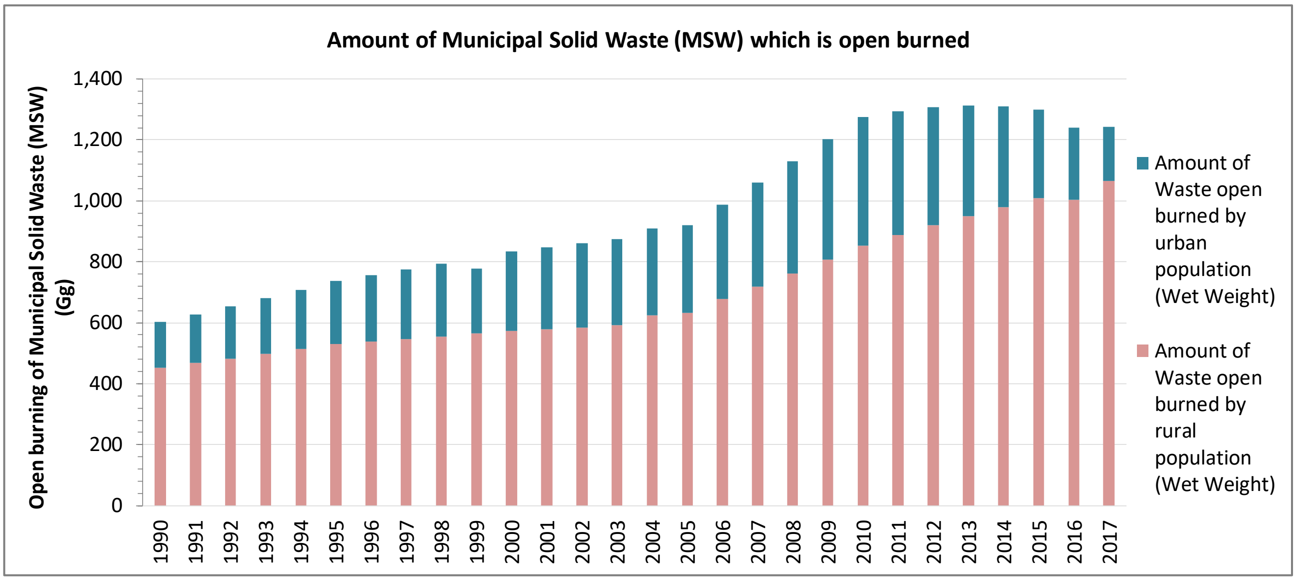


Figure 200 Municipal solid waste (MSW) open burned from urban and rural population - 1990 - 2017

Table 322 Municipal solid waste (MSW) open burned from total, urban and rural population

	Total Municipal solid waste (MSW) which is open burned		MSW from urban population which is open burned		MSW from rural population which is open burned	
	Gg	%	Gg	%	Gg	%
1990	603.221	100%	452.109	75%	151.112	25%
1991	627.802	100%	467.730	75%	160.072	25%
1992	653.650	100%	482.991	74%	170.658	26%
1993	680.438	100%	498.588	73%	181.851	27%
1994	708.222	100%	514.509	73%	193.714	27%
1995	737.043	100%	530.762	72%	206.281	28%

[224] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, Part B, Vol 5 Waste, Chap. 5.C.2 Open burning of waste, sub-chapter 3.2 Tier 1 default approach.

	Total Municipal solid waste (MSW) which is open burned		MSW from urban population which is open burned		MSW from rural population which is open burned	
	Gg	%	Gg	%	Gg	%
1996	755.194	100%	538.968	71%	216.226	29%
1997	773.875	100%	547.244	71%	226.631	29%
1998	793.121	100%	555.598	70%	237.523	30%
1999	778.072	100%	563.863	72%	214.209	28%
2000	833.351	100%	572.528	69%	260.823	31%
2001	847.205	100%	578.592	68%	268.613	32%
2002	861.183	100%	584.906	68%	276.278	32%
2003	875.506	100%	590.949	67%	284.557	33%
2004	908.233	100%	623.312	69%	284.921	31%
2005	921.222	100%	632.863	69%	288.360	31%
2006	987.103	100%	678.812	69%	308.290	31%
2007	1.058.864	100%	717.448	68%	341.416	32%
2008	1 129.323	100%	762.081	67%	367.241	33%
2009	1 201.828	100%	807.655	67%	394.173	33%
2010	1 276.420	100%	854.199	67%	422.220	33%
2011	1 294.649	100%	886.940	69%	407.709	31%
2012	1 306.734	100%	918.952	70%	387.782	30%
2013	1 312.144	100%	950.171	72%	361.973	28%
2014	1 310.304	100%	980.531	75%	329.773	25%
2015	1 300.612	100%	1 009.965	78%	290.647	22%
2016	1 238.940	100%	1 003.181	81%	235.759	19%
2017	1 243.639	100%	1 066.721	86%	176.919	14%
Trend						
1990 - 2017	*106%*	-	*136%*	-	*17%*	-
2005 - 2017	*35%*	-	*69%*	-	*-39%*	-
2016 - 2017	*0.4%*	-	*6%*	-	*-25%*	-

7.4.2.3 Choice of emission factors

Waste composition is one of the main factors influencing emissions from open burning of waste, as different waste types contain different amount of biogenic and fossil carbon content.

Waste types such as food waste, garden waste, paper and cardboard, wood, textiles, and nappies (disposable diapers) contain only biogenic carbon. Ash, dust, rubber and leather contain also certain amounts of non-fossil carbon. Some textiles, plastics (including plastics in disposable nappies), rubber and electronic waste contain the bulk part of fossil carbon in MSW. Paper (with coatings) and leather (synthetic) can also include small amounts of fossil carbon.

For Afghanistan it was possible to collect country specific data on waste composition. The data used in the inventory are based on expert judgement by national experts from Independent Directorate of Local Governance (IDLG), Municipality of Kabul and National Protection Agency (NEPA). In the following table the IPCC default value is also provided. The country specific data on waste composition is in the range of the IPCC default. The lower value for wood is due to lack of fuel for household. The lower value for food waste is due to the socio-economic situation of Afghanistan.

Table 323 Composition of waste open burned

	Food	Garden	Paper	Wood	Textile	Disposable nappies	Plastics, other inert	Total	Source
Waste composition - WF									
IPCC Default	40%	0%	11%	8%	3%	0%	38%	100%	TABLE 2.3, Vol. 5, Chapter 2, 2006 IPCC Guidelines
Country specific (CS)	33%	10%	10%	2%	2%	0%	43%	100%	

Default emission factors and default parameters for greenhouse gases were taken from IPCC 2006 Guidelines. It is *good practice* to apply these as no country-specific information is available.

Table 324 Default dry matter content, DOC content, total carbon content and fossil carbon fraction of different MSW components

MSW component	Dry matter content in % of wet weight [1] dm	Total carbon content in % of dry weight CF		Fossil carbon fraction in % of total carbon FCF	
	Default	Default	Range	Default	Range
Paper/cardboard	90	46	42 - 50	1	0 - 5
Textiles [3]	80	50	25 - 50	20	0 - 50
Food waste	40	38	20 - 50	-	-
Wood	85 4	50	46 - 54	-	-
Garden and Park waste	40	49	45 - 55	0	0
Nappies	40	70	54 - 90	10	10
Rubber and Leather	84	67	67	20	20
Plastics	100	75	67 - 85	100	95 - 100
Metal [6]	100	NA	NA	NA	NA
Glass [6]	100	NA	NA	NA	NA
Other, inert waste	90	3	0 - 5	100	50 - 100

Remark: for footnotes see 2006 IPCC Guidelines

Source: Table 2.4 (excerpt), Vol. 5, Chapter 2, 2006 IPCC Guidelines

<u>Oxidation factor (OX)</u>

The oxidation factor (OX) reflects the amount of CO_2 from open burning that is oxidized. The default oxidation factor of 58 % of carbon input was applied (TABLE 5.2, 2006 IPCC Guidelines Vol. 5, Chap. 5 (5.4.1).

<u>CH_4 emission factor</u>

For open burning of waste, a CH_4 emission factor of 6500 g_{CH4} / t MSW wet weight has been applied (2006 IPCC Guidelines Vol. 5, Chap. 5 (5.4.2)).

<u>N_2O emission factor</u>

For open burning of waste, a N_2O emission factor of 150 g_{N2O} / t MSW wet weight has been applied (TABLE 5.6, 2006 IPCC Guidelines Vol. 5, Chap. 5 (5.4.3).

Default emission factors for air pollutant were taken from the EMEP/EEA air pollutant emission inventory Guidebook 2016 and are presented in the following table.

Table 325 Non-GHG Emission factor for IPCC sub-category 5.C.2 Open burning

NOx (kg/Mg waste)		CO (kg/Mg waste)		NMVOC (kg/Mg waste)		SO_2 (kg/Mg waste)		Source: EMEP/EEA Guidebook 2016, Part B, Vol 5 Waste, Chap. 5.C.2 Open burning of waste
EF	type	EF	type	EF	type	EF	type	
3.18	D	55.83	D	1.23	D	0.11	D	Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning (page. 6)[225]

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

7.4.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 5.C.2 *Open Burning* are presented in the following table.

Table 326 Uncertainty for IPCC sub-category 5.C.2 Open Burning.

Uncertainty	CO_2	CH_4	N_2O	Reference
Activity data (AD)	147%	147%	147%	2006 IPCC GL, Vol. 5, Chap. 3.7 Based on Table 3.5
Emission factor (EF)	±40%	±100%	±100%	2006 IPCC Guidelines Vol. 5, Chap. 5 (5.7.1)
Combined Uncertainty (U)	152%	178%	178%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent with the data reported in the population statistics, GDP statistics, which were used as surrogate data.

7.4.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency

⇒ plausibility checks of dips and jumps.

7.4.5 Source-specific recalculations

In INC and SNC the IPCC sub-category *5.C.2 Open burning* was not estimated. Therefore, there are no

[225] https://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/5-waste/5-c-2-open-burning/view

revisions.

7.4.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 327 Planned improvements for IPCC sub-category 5.C.2 Open burning

GHG source & sink category	Planned improvement	Type of improvement		Priority
5	Investigation on waste flow: collection, disposal, recycling, incineration with energy and without energy recovery, open burning, composting, etc. (see **Error! Reference source not found.**) • Urban population • Rural population	AD	Accuracy Transparency Comparability Completeness	High
5.C	Investigation on amount and waste management practices regarding clinic waste, sludge, hazardous waste, etc. which is burned	AD		High
5.C	Investigation on open burning activities: fraction of population burning waste outside their houses and fraction of MSW burned at dump sites	AD		High
5.C	Investigation on fraction of waste, which is combustible	AD		High

7.5 Wastewater Treatment and Discharge (IPCC category 5.D)

The following section describes GHG emissions resulting from Wastewater Treatment and Discharge. According to 2006 IPCC Guidelines wastewater can be a source of methane (CH_4) when treated or disposed anaerobically. It can also be a source of nitrous oxide (N_2O) emissions. Carbon dioxide (CO_2) emissions from wastewater are not considered because these are of biogenic origin and should not be included in national total emissions.

Nitrous Oxide (N_2O)

There are two sources of N_2O emissions:

- Indirect N_2O emissions from discharge of effluent into waterways, lakes and sea.
- Direct N_2O emissions from treatment plants which are low compared to indirect emissions

Nitrous oxide (N_2O) is associated with the degradation of nitrogen components in the wastewater, e.g., urea, nitrate and protein. Domestic wastewater includes human sewage mixed with other household wastewater, which can include effluent from shower drains, sink drains, washing machines, etc.

Methane (CH_4)

Wastewater as well as its sludge components can produce CH_4 if it degrades anaerobically. The extent of CH_4 production depends primarily on the quantity of degradable organic material in the wastewater, the temperature, and the type of treatment system. With increases in temperature, the rate of CH_4 production increases. This is especially important in uncontrolled systems and in warm climates.

The term “sanitation chain” which refers to the sequence according to which FS is “handled” along the way from production at the level of the households until its disposal is shown in in the following figure.

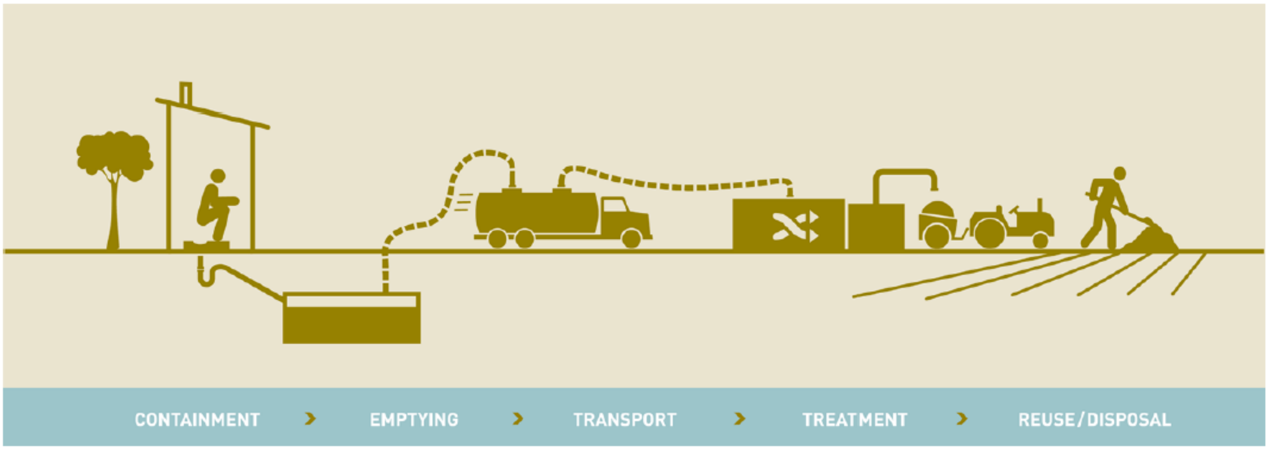


Figure 201 The Sanitation Chain

Source: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)(2016): SFD Report Kabul, Afghanistan.

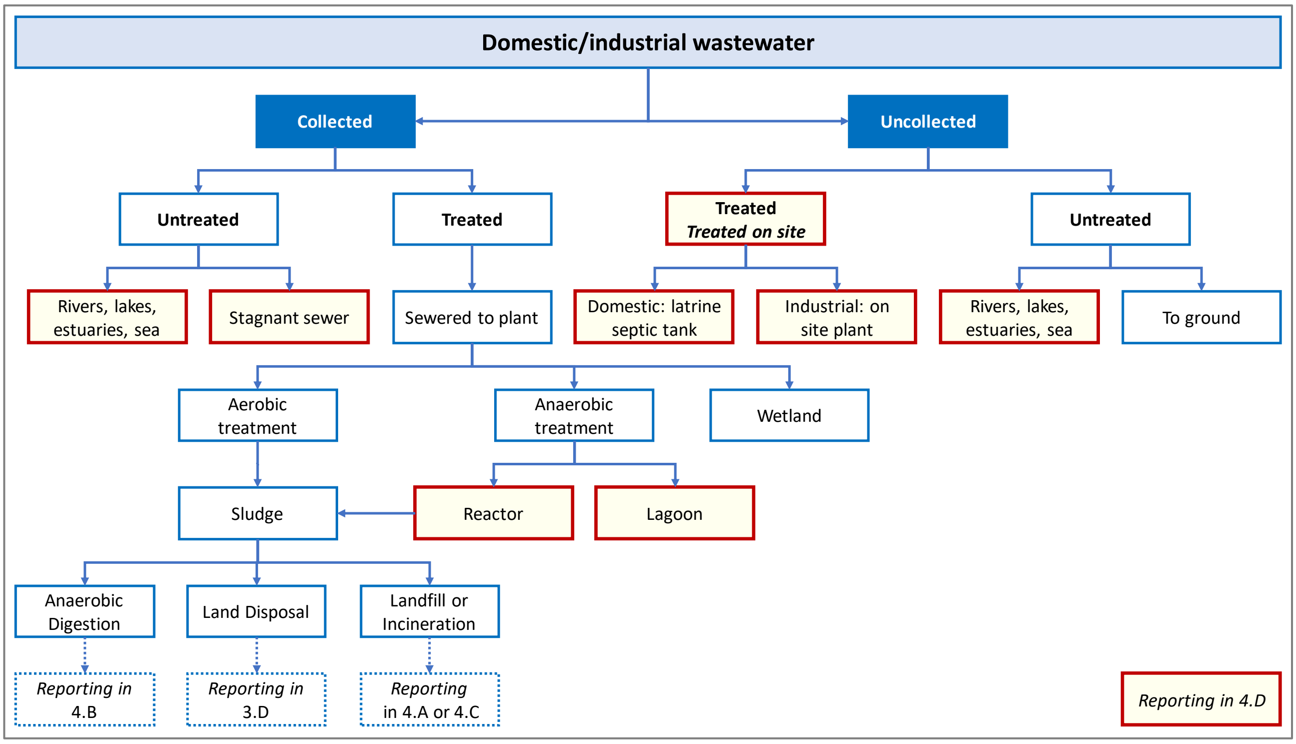


Figure 202 **Wastewater treatment systems and discharge pathways**[226]

Wastewater is defined as

- domestic effluent consisting of blackwater (excreta, urine and fecal sludge) and grey-water (kitchen and bathing wastewater), or
- water from commercial establishments and institutions, including hospitals, or
- industrial effluent, storm water and other urban run-off.

Sanitation services have, mainly understandably, been given less priority than water supply since people tend to grant more urgency to the provision of water. Access to improved sanitation can have different interpretations from one country to another. Septic tanks, latrines, river and lake discharge and sewer are om many developing countries the main domestic treatment and discharge facilities. In 2016, among the five treatment and discharge systems, latrine facilities were the commonest.

In most developing countries, data on urban and rural areas are generally scarce and, if available, reliable only for the last year. However, according to available data, wastewater collection in rural areas is very low compared to urban areas.

[226] Source: 2006 IPCC Guidelines, Volume 5: Waste, Chapter 6: Wastewater Treatment and Discharge - Figure 6.1

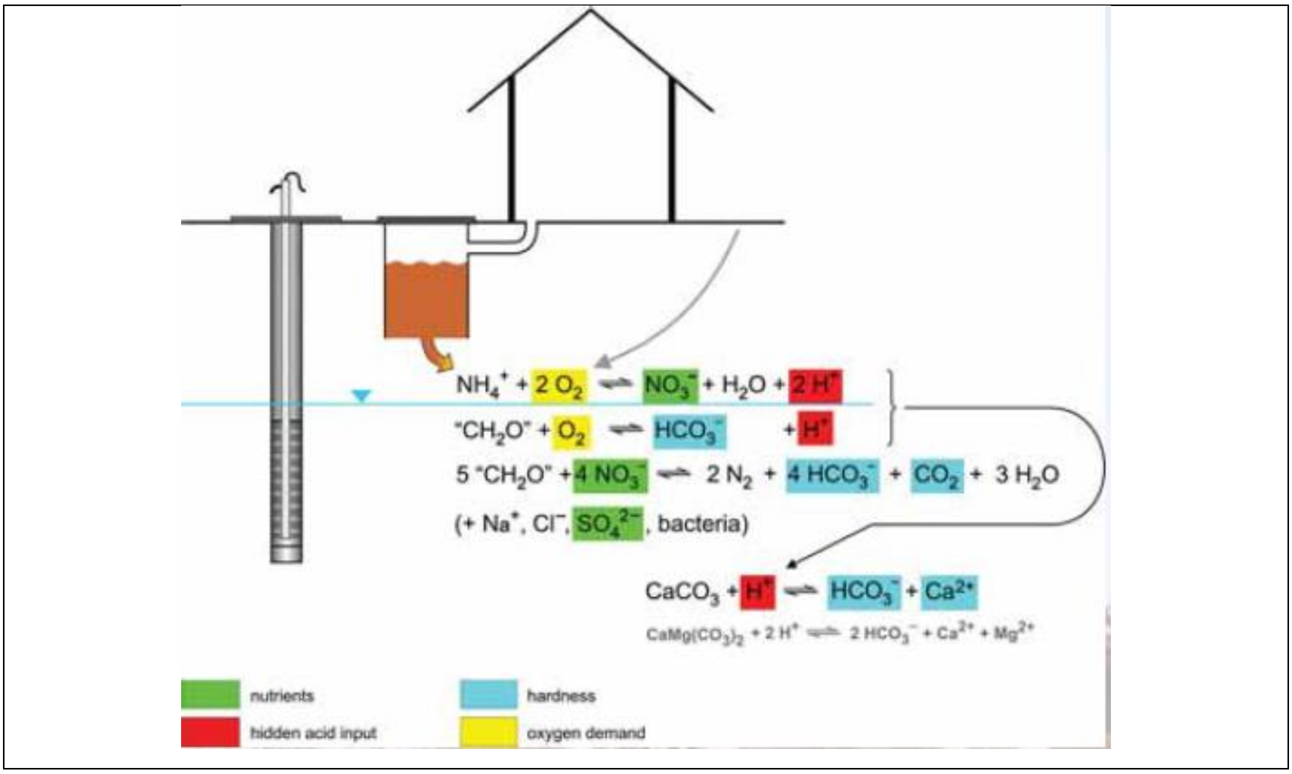


Figure 203 Main process of wastewater influence on shallow groundwater

Source: Federal Institute for Geosciences and Natural Resources (BGR): Groundwater resources at risk Kabul, Afghanistan

Wastewater Situation in Afghanistan

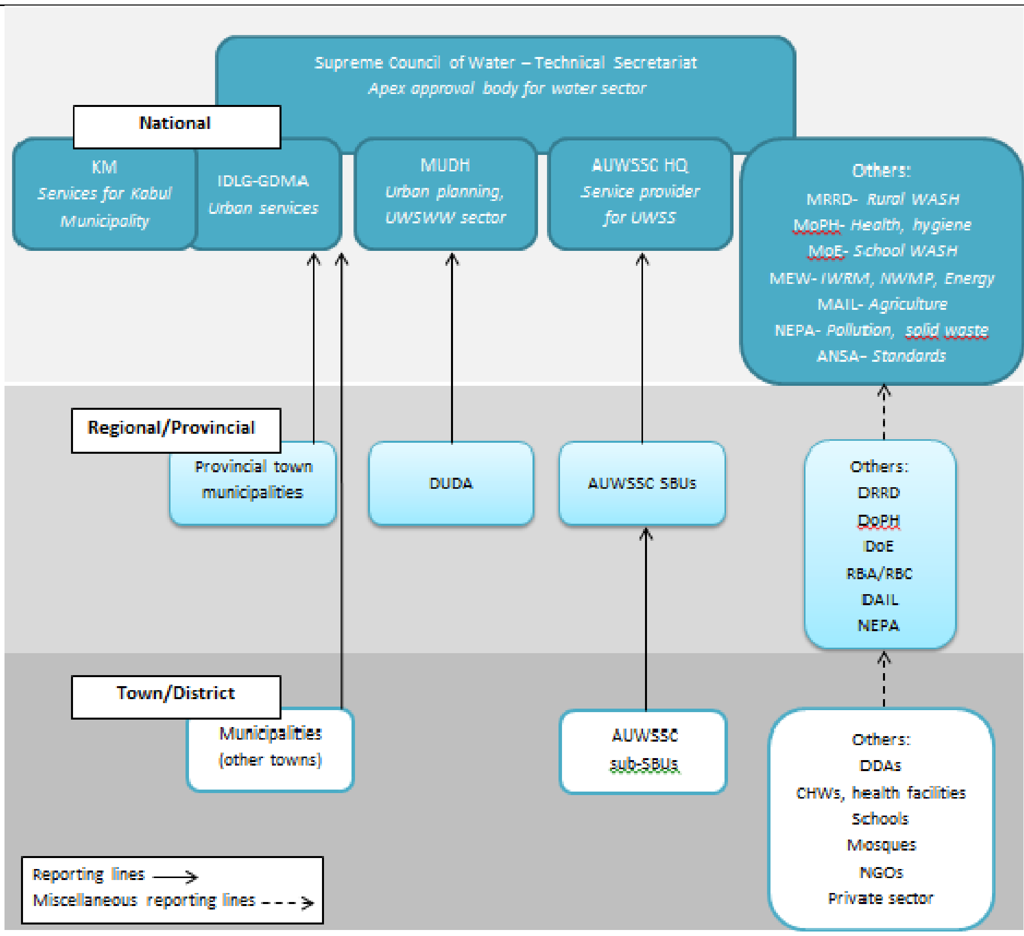
Migrations from rural to urban, industrial sector and increasing population growth have considerable affection creating wastewater production. In low income countries, like Afghanistan, organization, industrialization, rapid population growth, unplanned urbanization and informal activities are one of the significant issues regarding wastewater and water pollution. At the same time, the sanitation-related component of MDGs 7 (10) is less likely to be achieved within the targeted timeframe.

Water supply, sanitation and poor management systems are the key problems: so far, the produced wastewater rarely receive adequate treatment. This is mainly because of the lack of regulations and management programmes needed for the design, operation and maintenance of individual sanitation units.

The role of designing, planning, coordination and monitoring of the Water Supply and Sanitation functions in Afghanistan the following institutions were delegated

- for urban areas: Ministry of Urban Development and Housing (MUDH) through the 2005 Urban Water Supply and Sewerage Sector Policy
- for rural areas: Ministry of Rural Rehabilitation and Development (MRRD) together with the line ministries, Ministry of Public Health (MoPH) and Ministry of Education (MoE)) through the Rural Water Supply, Sanitation and Irrigation Program (RuWatSIP) named Water Supply, Sanitation and Hygiene Promotion (WASH).

In the following figure is presented the legal and institutional framework of the sanitation sector (MUDH 2014) and a schematic of key institutions linked to Integrated Wastewater Management at the national, region-al/provincial and town/districts levels, respectively.



Law and Regulations	Standards	Policies	Guidelines
• Water Law (2009) • Environment Law (2009) • Law of Municipalities (existing)/Municipal Law (draft 2012) • AUWSSC Statues	• Waster Resources Qualits Standards	• Urban Water Supply and Sewerage Sector Policy (2005, MUDH) • Urban Water Supply and Sewerage Sector Policy (2014, MUDH) • National Rural WASH Policy (2010, MRRD) • Policies of NEPA (solid waste), MoPH (Hygiene)	• Integrated solid waste manamgent programm manual (IDLG) • Latrine designs and WASH package for schools (MoE) • Rural Waster, Sanistation and Hygiene implementation manural (MRRD) • Implementation manual for low-cost household laterines (MRRD) • AUWSSC's SBU and other utilities management system guidelines • Procurement (policy) (AUWSSC) • Public private partnership guidelines (IDLG)

Figure 204 Legal and Institutional Framework of the sanitation sector (MUDH 2014) and Schematic of key institutions linked to Integrated Waste Water Management at the national, region-al/provincial and town/districts levels, respectively (GIZ 2015)

Source: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)(2016): SFD Report Kabul, Afghanistan.

7.5.1 Source category description

GHG emissions/ removals	CO_2	CH_4	N_2O
Estimated			
5.D Wastewater Treatment and Discharge	NA	✓	✓
Key Category	-	LA 1990, 2017; TA	LA 1990, 2017; TA
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential			
LA – Level Assessment (in year); TA – Trend Assessment			

Emissions from the IPCC sub-category 5.D *Wastewater Treatment and Discharge* are a small source of GHGs in Afghanistan:

- in 1990 about 4.3% of the total national GHG emissions and 2.9% of total N_2O emissions arose from the waste sector, whereas CH_4 emissions make up about 7.1%.
- in 2005 about 4.5% of the total national GHG emissions and 7.1% of total N_2O emissions arose from the waste sector, whereas CH_4 emissions make up about 2.5%.
- in 2017 about 2.8% of the total national GHG emissions and 3.0% of total N_2O emissions arose from the waste sector, whereas CH_4 emissions make up about 6.2%.

In the period 1990 – 2017 the GHG emissions increased by 50.9% CH_4. In the period 2005 - 2017 the CH_4 emissions increased by 17.5% mainly due to

- growing population,
- improved wastewater management: from open defecation and unimproved systems to improved latrine and other;
- installation of septic tanks.

In the period 1990 – 2017 the N_2O emissions increased by 90.1%. In the period 2005 - 2017 the N_2O emissions increased by 34.5%.

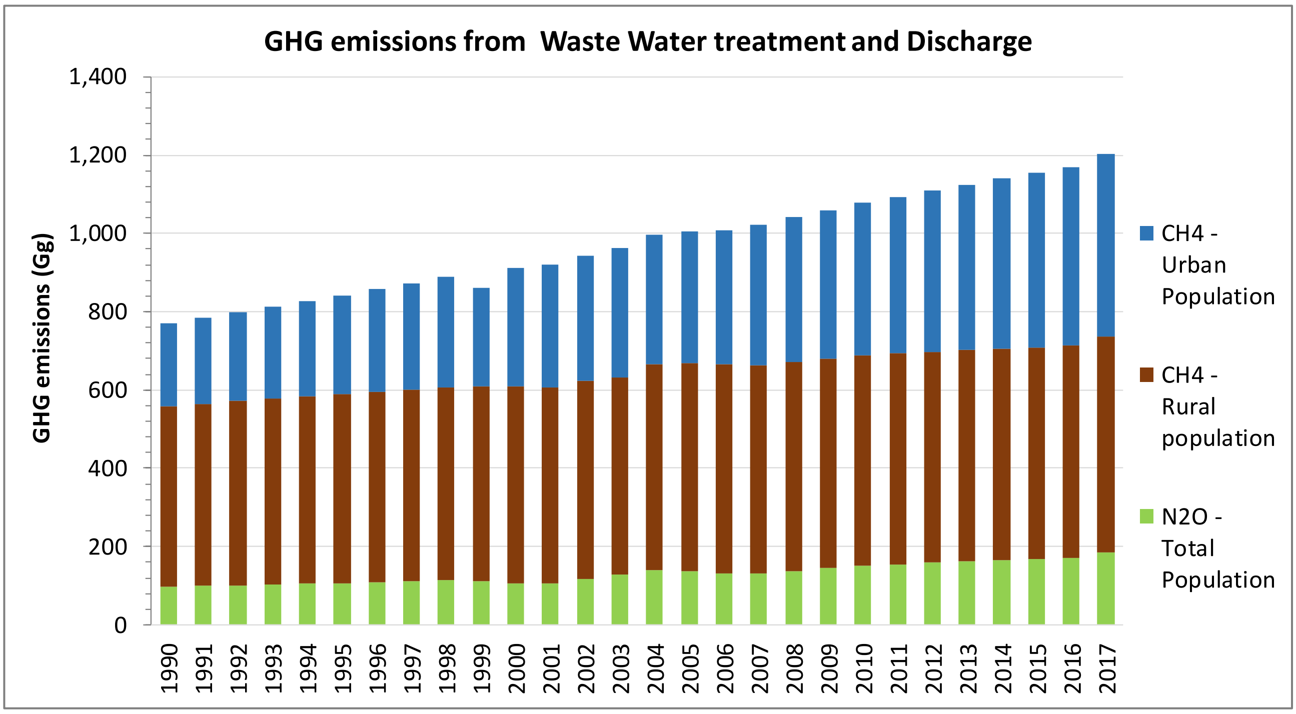


Figure 205 Emissions from IPCC sub-category 5.D Wastewater Treatment and Discharge 1990 - 2017

Table 328 Emissions from IPCC sub-category 5.D Wastewater Treatment and Discharge 1990 - 2017

Emissions	TOTAL GHG	CH_4				N_2O	
		Population				Total population	
		Total		*Urban*	*Rural*		
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg	*Gg*	*Gg*	Gg CO_2 equivalent	Gg
1990	772	675	27	9	18	97	0.3
1991	785	686	27	9	19	99	0.3
1992	798	698	28	9	19	101	0.3
1993	813	710	28	9	19	103	0.3
1994	827	722	29	10	19	105	0.4
1995	842	735	29	10	19	107	0.4
1996	857	748	30	10	19	109	0.4
1997	873	762	30	11	20	111	0.4
1998	889	775	31	11	20	113	0.4
1999	861	749	30	10	20	112	0.4
2000	910	804	32	12	20	107	0.4
2001	919	814	33	12	20	105	0.4
2002	943	825	33	13	20	118	0.4
2003	964	835	33	13	20	128	0.4
2004	998	859	34	13	21	139	0.5
2005	1,004	867	35	13	21	137	0.5
2006	1,008	876	35	14	21	132	0.4
2007	1,023	893	36	14	21	130	0.4
2008	1,041	904	36	15	21	137	0.5
2009	1,060	916	37	15	21	144	0.5
2010	1,079	927	37	16	21	152	0.5
2011	1,094	939	38	16	22	155	0.5
2012	1,109	951	38	16	22	158	0.5
2013	1,124	963	39	17	22	161	0.5
2014	1,139	975	39	17	22	165	0.6
2015	1,155	987	39	18	22	168	0.6
2016	1,169	998	40	18	22	172	0.6
2017	1,203	1,018	41	19	22	184	0.6
Trend							
1990 - 2017	*55.9%*	*50.9%*	*50.9%*	*119.4%*	*19.3%*	*90.1%*	*90.1%*
2005 - 2017	*19.8%*	*17.5%*	*17.5%*	*39.2%*	*3.8%*	*34.5%*	*34.5%*
2016 - 2017	*2.9%*	*2.1%*	*2.1%*	*2.6%*	*1.6%*	*7.5%*	*7.5%*

7.5.2 Methodological issues

7.5.2.1 Choice of methods

For estimating the CH_4 emissions the 2006 IPCC Guidelines Tier 1 approach[227] has been applied. The steps for *good practice* in inventory preparation for CH_4 from domestic wastewater are as follows:

Step 1: Application of equation 6.3 (see Chapter7.5.2.2) to estimate total organically degradable carbon in wastewater (TOW).

Step 2: Mapping the wastewater treatment systems and discharge pathways.
Application of Equation 6.2 (see Chapter 7.5.2.3) to obtain the emission factor for each domestic wastewater treatment/discharge pathway or system.

Step 3: Application of equation 6.1 to estimate emissions, adjust for possible sludge removal and/or CH_4 recovery and sum the results for each pathway/system.

The principal factor in determining the CH_4 generation potential of wastewater is the amount of degradable organic material in the wastewater. Common parameters used to measure the organic component of the wastewater are the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Under the same conditions, wastewater with higher COD, or BOD concentrations will generally yield more CH_4 than wastewater with lower COD (or BOD) concentrations.

The BOD concentration indicates only the amount of carbon that is aerobically biodegradable. The standard measurement for BOD is a 5-day test, denoted as BOD_5.

EQUATION 6.1 CH_4 Emissions from domestic wastewater (2006 IPCC GL, Vol. 5, Chap.6)

$$\boldsymbol{CH_4\ emissions} = \left[\sum_i (U_i \times T_{i,j} \times EF_i)\right] \times (TOW - S) - R$$

Where:	CH_4 Emissions	= CH_4 emissions in inventory year (kg CH_4)
	TOW	= total organics in wastewater in inventory year (kg BOD)
	S	= organic component removed as sludge in inventory year (kg BOD)
	U_i	= fraction of population in income group i in inventory year
	$T_{i,j}$	= degree of utilisation of treatment/discharge pathway or system, j, for each income group fraction i in inventory year.
	i	= income group: rural, urban high income and urban low income
	j	= each treatment/discharge pathway or system
	EFj	= emission factor (kg CH_4 / kg BOD)
	R	= amount of CH_4 recovered in inventory year (kg CH_4)

[227] Source: 2006 IPCC Guidelines, Volume 5: Waste, Chapter 6: Wastewater Treatment and Discharge, 6.2.2.1 Choice of Method

No higher tiers are given, so it is *good practice* to estimate N_2O from domestic wastewater effluent using the 2006 IPCC Guidelines Tier 1 approach[228] has been applied.

EQUATION 6.7 N_2O Emissions from wastewater effluent (2006 IPCC GL, Vol. 5, Chap.6)

$$N_2O\ emissions = N_{effluent} \times EF_{effluent} \times \frac{44}{28}$$

Where:	N_2O emissions	= N_2O emissions in inventory year (Gg)
	$N_{effluent}$	= nitrogen in the effluent discharged to aquatic environments (kg N)
	$EF_{effluent}$	= emission factor for N_2O emissions from discharged to wastewater (kg N_2O-N/kg N)
	44/28	= conversion of kg N_2O-N into kg N_2O.

For estimating the air pollutants emissions (NOx, CO, NMVOC, SO_2) the Tier 1 approach[229] of the EMEP/EEA air pollutant emission inventory guidebook 2016 has been applied. From wastewater treatment and discharge, the air pollutants emissions NOx, CO, and SO_2 do not arise.

Tier 1 approach for emissions from wastewater handling

$$Emissions_{pollutant} = AD \times EF_{pollutant}$$

Where:

$Emissions_{pollutant}$	= emissions of a given pollutant (Gg pollutant)
AD	= amount of wastewater handled landfilled (Gg)
Emission factor $_{pollutant}$	= default emission factor of a given pollutant (mg/m³ waste water handled)
Pollutant	= NOx, CO, NMVOC, SO_2

As the emission factor for NMVOC is expressed in mg/m³ wastewater handled, it was at this stage not possible to estimate NMVOC emissions from wastewater handling and discharge.

7.5.2.2 Choice of activity data

The activity data for this source category is the total amount of organically degradable material in the wastewater (TOW). This parameter is a function of human population and BOD generation per person. It is expressed in terms of biochemical oxygen demand (kg BOD/year). The equation for TOW is:

EQUATION 6.3 Total Organically Degradable Material in Domestic Wastewater (2006 IPCC GL, Vol. 5, Chap.6.2.2.3)

$$TOW = P \times BOD \times 0.001 \times I \times 365$$

Where:	TOW	= total organics in wastewater in inventory year, kg
	BOD/yr	= country population in inventory year
	BOD	= country-specific per capita BOD in inventory year, g/person/day, see Table 6.4.
	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.)

[228] Source: 2006 IPCC Guidelines, Volume 5: Waste, Chapter 6: Wastewater Treatment and Discharge, 6.3.1.1 Choice of Method

[229] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, 5.D Wastewater handling, sub-chapter 3.2 Tier 1 default approach.

Biochemical oxygen demand (BOD)

Default Biochemical oxygen demand (BOD) for the region Asia, Middle East, Latin America	40.00 g/person/day	Source: 2006 IPCC GL TABLE 6.4, Vol. 5, Chap. 6, p. 6.14;

The main source of activity data – population by settlement is NSIA and UN statistic. In chapter 7.1.2 Country-specific issues above the activity data and the underlying assumptions are descripted. Chapter 7.1.2.4 Population of Afghanistan the relevant time series 1990 – 2017 can be found.

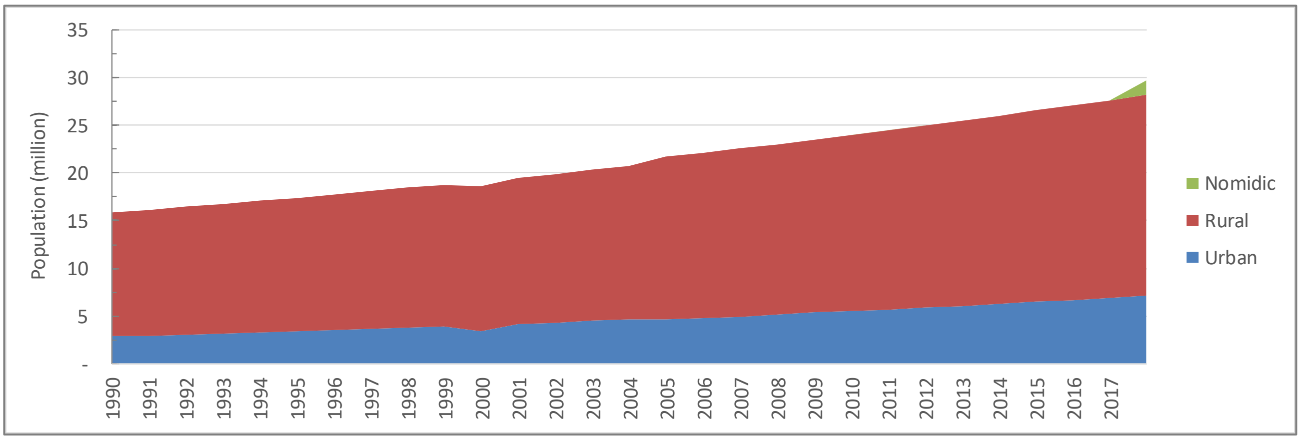


Figure 206: Population of Afghanistan 1950 - 2017

The second step was mapping the wastewater treatment systems and discharge pathways according to national circumstances. For this the following reports were reviewed:

- National Risk and Vulnerability Assessment (NRVA) 2005
- National Risk and Vulnerability Assessment (NRVA) 2007/2008
- National Risk and Vulnerability Assessment (NRVA) 2011 – 2012
- Afghanistan Living Conditions Survey (ALCS) 2013-2014
- Afghanistan Living Conditions Survey (ALCS) 2016-2017

The latest report of the Afghanistan Living Conditions Survey (ALCS) provided complete information regarding population, by main toilet facility, and by residence, which were taken as 'baseline 2016'.

Table 329 Population, by main toilet facility, and by residence in 2016

Main toilet facility	Urban	Rural	Kuchi	Total
Total	100%	100%	100%	100%
Pit latrine - with slab / covered pit	8.7%	17.2%	2.8%	14.5%
Pit latrine - without slab / open pit	15.1%	35.9%	7.4%	29.5%
Ventilated improved pit (VIP) latrine	13.7%	6.9%	0%	8.2%
Flush to piped sewer system	4.5%	0.6%	0%	1.5%
Flush/pour flush toilet to septic tank	33.7%	1.1%	0%	8.8%
Flush/pour flush toilet to pit	4.1%	0.3%	0%	1.2%
Flush/pour flush toilet to elsewhere	0.7%	0.1%	0%	0.2%

Main toilet facility	Urban	Rural	Kuchi	Total
Single/double vault - with urine diversion	10.5%	7.3%	0.5%	7.7%
Single/double vault - without urine diversion	7.9%	12.9%	4.3%	11.3%
No facility - open field, bush	0.5%	13.3%	80.7%	13.6%
Other	0.4%	4.4%	4.3%	3.5%

Source: Afghanistan Living Conditions Survey (ALCS) 2016-2017, Table 10.12 Proportion of population, by residence, and by level of sanitation service.

The data above was compared with international data provided for Afghanistan:

2016	WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP)(2017): Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines. Geneva.[230]
2000 – 2015	WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP)(data for the time series 2000 – 2015), who has reported country, regional and global estimates of progress on drinking water, sanitation and hygiene (WASH) since 1990.[231]
1993	WHO/UNICEF Joint Monitoring Programme & World Health Organization. (1993). Water supply and sanitation sector monitoring report : 1993 (sector status as of 31 December 1991. World Health Organization.[232]

The above provided data was aggregated according to the type of treatment and discharge pathway/system which is presented in the following table, and a consistent time-series series is prepared using interpolation and extrapolation.

Further differentiation was done according to the split provided in the 2006 IPCC Guidelines[233].

Type of treatment and discharge pathway or system	Comments
Untreated system	
Open defecation	Rivers with high organics loadings can turn anaerobic.
River and lake discharge	Rivers with high organics loadings can turn anaerobic.
Stagnant sewer	calculated in order to have always 100%
Treated system	
Flowing sewer (open or closed)	Fast moving, clean. (Insignificant amounts of CH_4 from pump stations, etc)
Centralized, aerobic treatment plant	Must be well managed. Some CH_4 can be emitted from settling basins and other pockets.

[230] Available (22 April 2019) on https://www.who.int/mediacentre/news/releases/2017/launch-version-report-jmp-water-sanitation-hygiene.pdf
[231] Available (20 March 2019) on https://washdata.org/data/household#!/table?geo0=region&geo1=sdg
[232] Available (20 March 2019) on https://washdata.org/report/jmp-1993-report
[233] Table 6.3, Chap. 6.2.2.2, Volume 5, 2006 IPCC Guidelines

Type of treatment and discharge pathway or system	Comments
Centralized, aerobic treatment plant	Not well managed. Overloaded.
Anaerobic digester for sludge	CH_4 recovery is not considered here.
Anaerobic reactor	CH_4 recovery is not considered here.
Anaerobic shallow lagoon	Depth less than 2 metres, use expert judgment.
Anaerobic deep lagoon	Depth more than 2 metres
Septic system	Half of BOD settles in anaerobic tank.
Latrine (family)	Dry climate, ground water table lower than latrine, small family (3-5 persons)
Latrine (many user)	Dry climate, ground water table lower than latrine, communal (many users)
Latrine	Wet climate/flush water use, ground water table higher than latrine
Latrine	Regular sediment removal for fertilizer

Wastewater discharge to Kabul River ©UNEP

Table 330 Assumptions for mapping the wastewater treatment systems and discharge pathways for 1990, 2000 and 2016

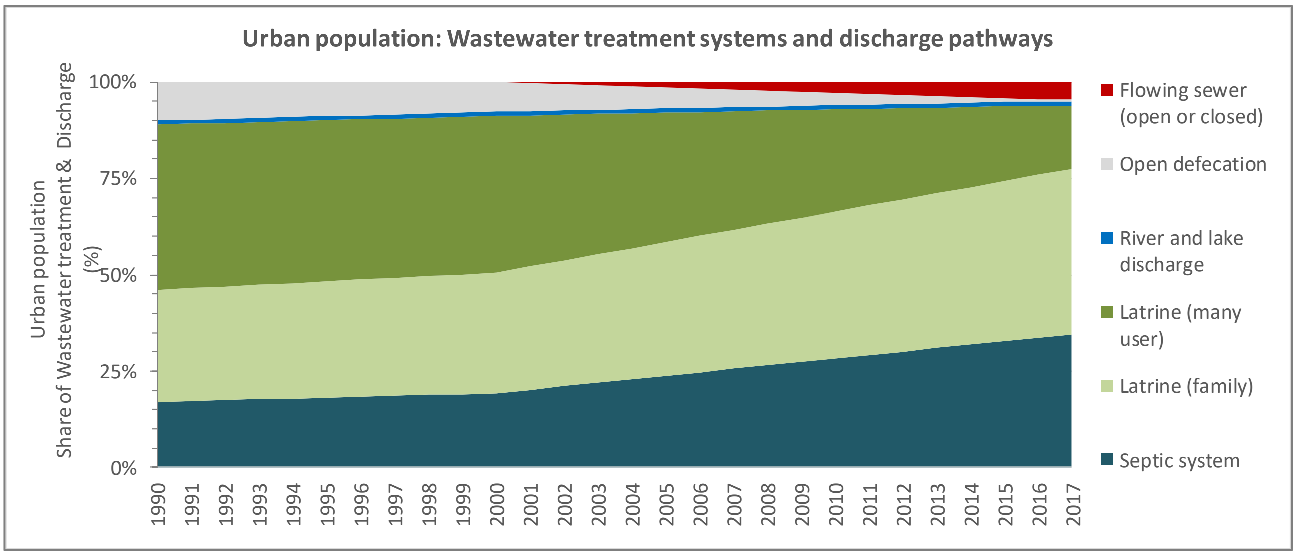
Parameter	Parameter description	Unit	Parameter Source	Coefficient		1990		2000		2016	2017
				1990 - 2000	2000-2015						
P	Population	capita	NSIA/UN			16,120,600		19,532,684		27,657,145	29,724,323
P_{urban}	Urban population	share	NSIA/UN			18%		21%		25%	24%
$P_{urban-high}$	Urban high-income population	share	assuming 50% of the urban population belongs to high income population			6%		7%		8%	8%
$P_{urban-low}$	Urban low-income population	share				12%		14%		17%	16%
P_{rural}	Rural population	share	NSIA/UN (see Chapter			82%		79%		75%	71%
P_{kuchi}	Kuchi population	share	NSIA/UN			0%		0%		0%	5%
BOD	biochemical oxygen demand	g/person/day	TABLE 6.4, Vol. 5, Chap. 6; 2006 IPCC GL, p. 6.14			40.00		40.00		40.00	40.00
	conversion g BOD to kg BOD	default				0.001		0.001		0.001	0.001
I	correction factor for co-discharge of industrial WW	default for co-discharge	EQUATION 6.3, Vol. 5, Chap. 6; 2006 IPCC GL, p. 6.13			1		1		1	1
	conversion to year	days per year				365		365		365	365
TOW	Total organically degradable material in domestic WW	TOW in kg BOD/year	EQUATION 6.3, Vol. 5, Chap. 6; 2006 IPCC GL, p. 6.13			235,360,760		285,177,186		403,794,317	403,794,317
B(0)	max. CH_4 producing capacity	CH_4/kg BOD	TABLE 6.2, Vol. 5, Chap. 6; 2006 IPCC GL, p. 6.12			0.6		0.6		0.6	0.6

Parameter	Parameter description	Unit	Parameter Source	Coefficient (extrapolation with 50% of the trend 2000 – 2016)		1990	1991-1999	2000 WHO/UNICEF (2017): JMP 2017, Annex 4, page 77 and Expert Judgement	2001-2015	2016 NSIA (2018): ALCS 2017/18	2017
				1990-2000	2000-2016						
Share Untreated system - Urban population - high income						*11.0%*		8.8%		*6.1%*	
	Open defecation	%	Extrapolation based on Expert judgement Interpolation based on • WHO/UNICEF (2017): JMP 2017, Annex 4, page 77 and Expert Judgement • NSIA (2018): ALCS 2017/18	-0.22%	-0.45%	9.9%	extrapolation with 50% of the trend 2000 - 2016	7.7%	interpolation	0.5%	
	River and lake discharge	%	Constant (Expert judgement)	0.00%	0.00%	1.1%		1.1%	As of 2000	1.1%	As of 2016
	Stagnant sewer	%	Extrapolation based on Expert judgement	0.00%	0.00%	0.0%	As of 2000	0.0%	As of 2016 & 2000	0.0%	
	Flowing sewer (open or closed)	%	Interpolation based on • WHO/UNICEF (2017): JMP 2017, Annex 4, page 77 and Expert Judgement • NSIA (2018): ALCS 2017/18	0.14%	0.28%	0.0%		0.00%	interpolation	4.5%	
Share Treated system - Urban population - high income						*89.0%*		91.2%		*93.7%*	
	Centralized, aerobic treatment plant	%	Extrapolation based on Expert judgement	0.00%	0.00%	0.0%		0.0%		0.0%	
	Centralized, aerobic treatment plant	%	Interpolation based on • WHO/UNICEF (2017): JMP 2017, Annex 4, page 77 and Expert Judgement • NSIA (2018): ALCS 2017/18	0.00%	0.00%	0.0%		0.0%		0.0%	
	Anaerobic digester for sludge	%		0.00%	0.00%	0.0%	As of 2000	0.0%	As of 2016 & 2000	0.0%	
	Anaerobic reactor	%		0.00%	0.00%	0.0%		0.0%		0.0%	
	Anaerobic shallow lagoon	%		0.00%	0.00%	0.0%		0.0%		0.0%	As of 2016
	Anaerobic deep lagoon	%		0.00%	0.00%	0.0%		0.0%		0.0%	
	Septic system	%		0.45%	0.90%	17.0%	extrapolation with 50% of the trend 2000 - 2016	19.28%		33.7%	
	Latrine (family)			0.34%	0.68%	29.1%		31.3%	interpolation	42.2%	
	Latrine (many user)	%		-0.71%	-1.43%	42.9%		40.6%		17.8%	
	Latrine	%		0.00%	0.00%	0.0%	As of 2000	0.0%	As of 2016 & 2000	0.0%	
	Latrine	%		0.00%	0.00%	0.0%		0.0%		0.0%	

Parameter	Parameter description	Unit	Parameter Source	Coefficient (extrapolation with 50% of the trend 2000 – 2016)		1990	1991-1999	2000 WHO/UNICEF (2017): JMP 2017, Annex 4, page 77 and Expert Judgement	2001-2015	2016 NSIA (2018): ALCS 2017/18	2017
				1990-2000	2000-2016						
Share Untreated system - Urban population - low income						*11.0%*		8.8%		*6.1%*	
	Open defecation	%	Extrapolation based on Expert judgement Interpolation based on • WHO/UNICEF (2017): JMP 2017, Annex 4, page 77 and Expert Judgement • NSIA (2018): ALCS 2017/18	-0.22%	-0.45%	9.9%	extrapolation with 50% of the trend 2000 - 2016	7.7%	interpolation	0.5%	As of 2016
	River and lake discharge	%	Constant (Expert judgement)	0.00%	0.00%	1.1%	As of 2000	1.1%	As of 2000	1.1%	
	Stagnant sewer	%	Extrapolation based on Expert judgement Interpolation based on • WHO/UNICEF (2017): JMP 2017, Annex 4, page 77 and Expert Judgement • NSIA (2018): ALCS 2017/18	0.00%	0.00%	0.0%		0.0%	As of 2016 & 2000	0.0%	
	Flowing sewer (open or closed)	%		0.14%	0.28%	0.0%		0.00%	interpolation	4.5%	
Share Treated system - Urban low income						*89.0%*		91.2%		*93.7%*	
	Centralized, aerobic treatment plant	%	Extrapolation based on Expert judgement Interpolation based on • WHO/UNICEF (2017): JMP 2017, Annex 4, page 77 and Expert Judgement • NSIA (2018): ALCS 2017/18	0.00%	0.00%	0.0%	As of 2000	0.0%	As of 2016 & 2000	0.0%	As of 2016
	Centralized, aerobic treatment plant	%		0.00%	0.00%	0.0%		0.0%		0.0%	
	Anaerobic digester for sludge	%		0.00%	0.00%	0.0%		0.0%		0.0%	
	Anaerobic reactor	%		0.00%	0.00%	0.0%		0.0%		0.0%	
	Anaerobic shallow lagoon	%		0.00%	0.00%	0.0%		0.0%		0.0%	
	Anaerobic deep lagoon	%		0.00%	0.00%	0.0%		0.0%		0.0%	
	Septic system	%		0.45%	0.90%	17.0%	extrapolation with 50% of the trend 2000 - 2016	19.28%	interpolation	33.7%	
	Latrine (family)	%		0.34%	0.68%	29.1%		31.3%		42.2%	
	Latrine (many user)	%		-0.71%	-1.43%	42.9%		40.6%		17.8%	
	Latrine	%		0.00%	0.00%	0.0%	As of 2000	0.0%	As of 2016 & 2000	0.0%	
	Latrine	%		0.00%	0.00%	0.0%		0.0%		0.0%	

Parameter	Parameter description	Unit	Parameter Source	Coefficient (extrapolation with 50% of the trend 2000 – 2016) 1990-2000	Coefficient 2000-2016	1990	1991-1999	2000 WHO/UNICEF (2017): JMP 2017, Annex 4, page 77 and Expert Judgement	2001-2015	2016 NSIA (2018): ALCS 2017/18	2017
Share Untreated system – rural population						42%		*36.1%*		*18.4%*	
	Open defecation	%	Extrapolation based on Expert judgement Interpolation based on • WHO/UNICEF (2017): JMP 2017, Annex 4, page 77 and Expert Judgement • NSIA (2018): ALCS 2017/18	37.3%	-1.14%	37.3%	extrapolation with 50% of the trend 2000 - 2016	31.6%	interpolation	13.3%	As of 2016
	River and lake discharge	%	Constant (Expert judgement)	4.5%	0.00%	4.5%	As of 2000	4.5%	As of 2000	4.5%	
	Stagnant sewer	%	Extrapolation based on Expert judgement	0.0%	0.00%	0.0%		0.0%	As of 2016 & 2000	0.0%	
	Flowing sewer (open or closed)	%	Interpolation based on • WHO/UNICEF (2017): JMP 2017, Annex 4, page 77 and Expert Judgement • NSIA (2018): ALCS 2017/18	-0.2%	0.04%	-0.2%		0.00%	interpolation	0.6%	
Share Treated system - rural population						*89.0%*		63.9%		*81.6%*	
	Centralized, aerobic treatment plant	%	Extrapolation based on Expert judgement	0.00%	0.00%	0.0%	As of 2000	0.0%	As of 2016 & 2000	0.0%	As of 2016
	Centralized, aerobic treatment plant	%	Interpolation based on • WHO/UNICEF (2017): JMP 2017, Annex 4, page 77 and Expert Judgement • NSIA (2018): ALCS 2017/18	0.00%	0.00%	0.0%		0.0%		0.0%	
	Anaerobic digester for sludge	%		0.00%	0.00%	0.0%		0.0%		0.0%	
	Anaerobic reactor	%		0.00%	0.00%	0.0%		0.0%		0.0%	
	Anaerobic shallow lagoon	%		0.00%	0.00%	0.0%		0.0%		0.0%	
	Anaerobic deep lagoon	%		0.00%	0.00%	0.0%		0.0%		0.0%	
	Septic system	%		0.45%	0.90%	17.0%	extrapolation with 50% of the trend 2000 - 2016	0.00%	interpolation	1.1%	
	Latrine (family)	%		0.34%	0.68%	29.1%		43.8%		73.3%	
	Latrine (many user)	%		-0.71%	-1.43%	42.9%		20.2%		7.2%	
	Latrine	%		0.00%	0.00%	0.0%	As of 2000	0.0%	As of 2016 & 2000	0.0%	
	Latrine	%		0.00%	0.00%	0.0%		0.0%		0.0%	

In the following figure are the share of different wastewater treatment systems and discharge pathways for the period 1990 to 2017 presented.



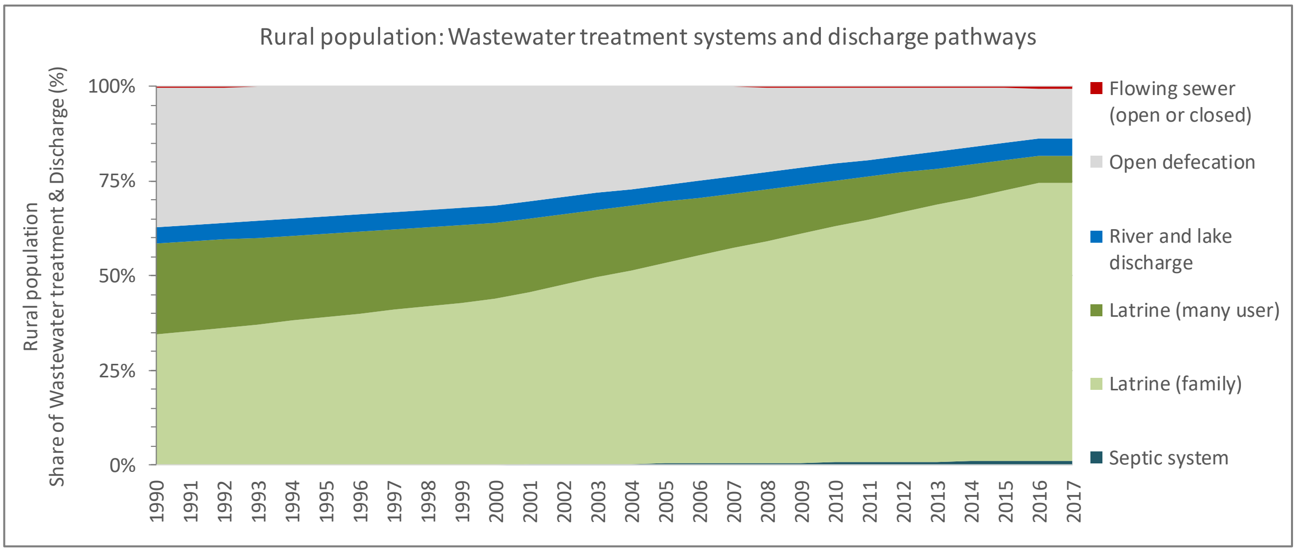


Figure 207 Distribution of different wastewater treatments and discharge system for urban and rural population - 1990 - 2017

7.5.2.3 Choice of emission factors

Emission factor for CH_4

The emission factor for a wastewater treatment and discharge pathway and system is a function of the maximum CH_4 producing potential (B_o) and the methane correction factor (MCF) for the wastewater treatment and discharge system. The Bo is the maximum amount of CH_4 that can be produced from a given quantity of organics (as expressed in BOD or COD) in the wastewater. The MCF indicates the extent to which the CH_4 producing capacity (Bo) is realised in each type of treatment and discharge pathway and system. Thus, it is an indication of the degree to which the system is anaerobic.

Equation 6.2 CH_4 Emission factor for each domestic wastewater treatment/discharge pathway or system (2006 IPCC GL, Vol. 5, Chap.6).

$$EF_j = B_0 \times MCF_j$$

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)

It is *good practice* is to use country-specific data for B_o, where available, expressed in terms of kg CH_4/kg BOD removed to be consistent with the activity data. No country-specific data are not available; therefore, the IPCC default value of 0.6 kg CH_4/kg BOD is applied (TABLE 6.2, *2006 IPCC GL, Vol. 5, Chap.6*.).

In the following table the default MCF values for domestic wastewater which is applied for the whole time-series, presented.

Table 331 Default MCF values for domestic wastewater

Type of treatment and discharge pathway or system	Comments	Default MCF [1]
Untreated system		
Sea, river and lake discharge	Rivers with high organics loadings can turn anaerobic.	0.1
Stagnant sewer	Open and warm	0.5
Flowing sewer (open or closed)	Fast moving, clean. (Insignificant amounts of CH_4 from pump stations, etc.)	0
Treated system		
Centralized, aerobic treatment plant	Must be well managed. Some CH_4 can be emitted from settling basins and other pockets.	0
Centralized, aerobic treatment plant	Not well managed. Overloaded.	0.3
Anaerobic digester for sludge	CH_4 recovery is not considered here.	0.8
Anaerobic reactor	CH_4 recovery is not considered here.	0.8
Anaerobic shallow lagoon	Depth less than 2 metres, use expert judgment.	0.2
Anaerobic deep lagoon	Depth more than 2 metres	0.8
Septic system	Half of BOD settles in anaerobic tank.	0.5
Latrine	Dry climate, ground water table lower than latrine, small family (3-5 persons)	0.1
Latrine	Dry climate, ground water table lower than latrine, communal (many users)	0.5
Latrine	Wet climate/flush water use, ground water table higher than latrine	0.7
Latrine	Regular sediment removal for fertilizer	0.1
[1] Based on expert judgment by lead authors of Vol. 5, Chapter 6, 2006 IPCC Guidelines.		

Source: TABLE 6.3, Vol. 5, Chapter 2, 2006 IPCC Guidelines

Emission factor for N_2O

The default IPCC emission factor for N_2O emissions from domestic wastewater nitrogen effluent is 0.005 kg N_2O-N/kg N (TABLE 6.11 Vol. 5, Chapter 2, 2006 IPCC Guidelines).

The Average protein supply is based on a 3-year average and is taken from FAOSTAT.

Table 332 Average protein supply (3-year average)

	Average protein supply (3-year average) g/capita/day	Source
1999-2001	32	FAOSTAT: Suite of Food Security Indicators [234]
2000/2002	29	
2001-2003	28	
2002-2003	31	
2003-2004	33	
2004-2005	34	
2005-2006	33	
2006-2007	31	
2007-2008	30	
2008-2009	31	
2009-2011	32	
2010-2021	33	
2011-2013	33	

Emission factor for NMVOC

Default emission factors for air pollutant were taken from the EMEP/EEA air pollutant emission inventory Guidebook 2016 and are presented in the following table.

Table 333 Non-GHG Emission factor for IPCC sub-category 5.D.2 Wastewater Treatment and Discharge

NOx (mg/m³ wastewater handled)		CO (mg/m³ wastewater handled)		NMVOC (mg/m³ wastewater handled)		SO_2 (mg/m³ wastewater handled)		Source EMEP/EEA Guidebook 2016, Part B, Vol 5 Waste, Chap. 5.D. Wastewater handling
EF	type	EF	type	EF	type	EF	type	
NA		NA		15	D	NA		Table 3-1 Tier 1 emission factors for source category 5.D Wastewater handling (page. 7)

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

As the emission factor for NMVOC is expressed in mg/m³ wastewater handled, it was at this stage not possible to estimate NMVOC emissions from wastewater handling and discharge.

[234] Available (03.01.2019) on http://www.fao.org/faostat/en/#data/FS

7.5.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 5.D *Wastewater Treatment and Discharge* are presented in the following table. The following parameters are believed to be very uncertain:

- The degrees to which wastewater in developing countries is treated in latrines, septic tanks, or removed by sewer, for urban high, urban low income groups and rural population (Ti,j).
- The fraction of sewers that are 'open', as well as the degree to which open sewers in developing countries are anaerobic and will emit CH_4. This will depend on retention time and temperature, and on other factors including the presence of a facultative layer and possibly components that are toxic to anaerobic bacteria (e.g., certain industrial wastewater discharges).
- The amount of industrial TOW that is discharged into open or closed domestic sewers for each country is very difficult to quantify.

Table 334 Uncertainty for IPCC sub-category 5.D Wastewater Treatment and Discharge.

Uncertainty	CH_4	N_2O	**Reference** 2006 IPCC GL, Vol. 5, Chap. 6
Activity data (AD)	71%		Table 6.7
		71%	Table 6.11
Emission factor (EF)	129%		Table 6.7
		261%	Table 6.11
Combined Uncertainty (U)	142%	270%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent.

7.5.4 Source-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources: national statistic, WHO/UNICEF and ALCS 2016-2017

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

⇒ time series consistency

⇒ plausibility checks of dips and jumps.

7.5.5 Source-specific recalculations

In INC and SNC the IPCC sub-category 5.D Wastewater Treatment and Discharge was not estimated. Therefore, there are no revisions.

7.5.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 335 Planned improvements for IPCC sub-category 5.D Wastewater Treatment and Discharge

GHG source & sink category	Planned improvement	Type of improvement		Priority
5.D	Investigation on wastewater flow: collection – treatment and discharge pathways and systems • Urban population (high / low income) • Rural population	AD	Accuracy Transparency Comparability Completeness	High
5.D	Estimation of amount of wastewater treated • Urban population (high / low income) • Rural population	AD		High
5.D	Use of metadata prepared for and submitted to WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP)	AD		High
5.D	Investigation of flow and amount of industrial wastewater	AD		High
5.D	Sludge separation and annual amount of sludge removal that is • dumped • applied to soil (agriculture) • incinerated	AD		Medium

8 Other

Afghanistan does not report any emissions under IPCC sector 6 Other.

9 Recalculations and Improvements

Recalculations of previously submitted inventory data are performed with the only purpose to improve the GHG inventory. This chapter quantifies the changes in emissions for all greenhouse gases compared to the previous submission.

9.1 Explanations and justifications for recalculations

Compiling an emission inventory includes **data collecting, data transfer** and **data processing**. Data has to be collected from different sources, for instance national statistics, plant operators, studies, personal information or other publications. The provided data must be transferred from different data formats and units into a unique electronic format to be processed further. The calculation of emissions by applying methodologies on the collected data and the final computing of time series into a predefined reporting format are further steps in the preparation of the final submission.

Finally, the submission must be delivered in due time. Even though a QA/QC system gives assistance so that potential error sources are minimized it is sometimes necessary to make some revisions (called recalculations) under the following circumstances:

- An emission source was not considered in the previous inventory.
- A source/data supplier has delivered new data. The causes might be: Previous data were preliminary data only (by estimation, extrapolation), improvements in methodology.
- Occurrence of errors in data transfer or processing: wrong data, unit-conversion, software errors, etc.
- Methodological changes: a new methodology must be applied to fulfil the reporting obligations caused by one of the following reasons:
    - to decrease uncertainties.
    - an emission source becomes a key source.
    - consistent input data needed for applying the methodology is no longer accessible.
    - input data for more detailed methodology is now available.
    - the methodology is no longer appropriate.

Detailed information on recalculations and their justifications can be found in the following subchapters

as well as the corresponding Sector-specific Chapters of the sectors Energy, IPPU, Agriculture, LULUCF and Waste, in which all methodological changes and activity data updates that led to recalculations of emissions with respect to the previous submission are listed.

Table 336 Recalculations done since INC and SNC compared to BUR submission 2019

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.1.a	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.1.a	Reallocation of fuel consumption (natural gas, solid fuels) to relevant subcategories – 1.A.2	AD	Transparency Comparability
1.A.1.a	use of default NCV of 2006 IPCC Guidelines	AD	Comparability
1.A.1.a	use of default EF of 2006 IPCC Guidelines	EF	Comparability

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.1.a	application of 2006 IPCC Guidelines	method	Comparability
1.A.1.b	No recalculation as this source is estimated the first time		
1.A.1.c.i	No recalculation as this source is estimated the first time		
1.A.2.c 2.B.2	Consumption of natural gas (activity data) for ammonia plant was completely allocate in 1.A.2.m. It was also assumed that the • entire amount of natural gas was burned; • no natural gas was used as feedstock (non-energy use); • no CO_2 recovery for downstream process – urea production.	AD	Accuracy Transparency Comparability
1.A.2.c 2.B.2	Reallocation of fuel consumption (natural gas, solid fuels) to relevant subcategories – 1.A.2	AD	Transparency Comparability
1.A.2.c 2.B.2	use of default NCV of 2006 IPCC Guidelines	AD	Comparability
1.A.2.c 2.B.2	use of default EF of 2006 IPCC Guidelines	EF	Comparability
1.A.2.c 2.B.2	application of 2006 IPCC Guidelines	method	Comparability
1.A.2.m	Fuel consumption data (activity data) was revised due to • revised activity data • consideration of imported fuels (reported by importers)(UNSD)	AD	Accuracy
1.A.2.m	Reallocation of fuel consumption (natural gas, solid fuels) to relevant subcategories – 1.A.2	AD	Transparency Comparability
1.A.2.m	use of default NCV of 2006 IPCC Guidelines	AD	Comparability
1.A.2.m	use of default EF of 2006 IPCC Guidelines	EF	Comparability
1.A.2.m	application of 2006 IPCC Guidelines	method	Comparability
1.A.3.a	Fuel consumption data (activity data) was revised due to • revised activity data consideration of imported fuels (reported by importers)(UNSD)	AD	Accuracy
1.A.3.a	use of default NCV of 2006 IPCC Guidelines	AD	Comparability
1.A.3.a	use of default EF of 2006 IPCC Guidelines	EF	Comparability
1.A.3.a	application of 2006 IPCC Guidelines	method	Comparability
1.A.3.b	Fuel consumption data (activity data) was revised due to • revised activity data consideration of imported fuels (reported by importers)(UNSD)	AD	Accuracy
1.A.3.b	use of default NCV of 2006 IPCC Guidelines	AD	Comparability
1.A.3.b	use of default EF of 2006 IPCC Guidelines	EF	Comparability
1.A.3.b	application of 2006 IPCC Guidelines	method	Comparability
1.A.4.b	Fuel consumption data (activity data) was revised due to revised activity data	AD	Accuracy
1.A.4.b	Waste and dung for fuel consumption data (activity data) was included	AD	Completeness
1.A.4.b	use of default NCV of 2006 IPCC Guidelines	AD	Comparability

GHG source & sink category	Revisions of data in INC (for the year 2005) and SNC (for the year 2013) ⇒ BUR submission 2019	Type of revision	Type of improvement
1.A.4.b	use of default EF of 2006 IPCC Guidelines	EF	Comparability
1.A.4.b	application of 2006 IPCC Guidelines	method	Comparability
2.A.1	2006 IPCC Guidelines TIER 2 methodology was applied	method	Accuracy
2.A.1	CS emission factor was applied	EF	Accuracy Transparency
3.A.1	application of 2006 IPCC Guidelines	method	Comparability
3.A.1	application of TIER 2approach for cattle	method	Comparability
3.A.1.a	use of default emission factor of 2006 IPCC Guidelines	EF	Comparability
3.A.1.b-j	use of default emission factor of 2006 IPCC Guidelines	EF	Comparability
3.A.1.a.	split of cattle in dairy, bulls and other non-dairy cattle	AD	Comparability
3.B	application of 2006 IPCC Guidelines	method	Comparability
3.B	use of CH_4 default emission factor of 2006 IPCC Guidelines	EF	Comparability
3.B	use of N2O default emission factor (direct emission) of 2006 IPCC Guidelines	EF	Comparability
3.B	use of N2O default emission factor (indirect emission) of 2006 IPCC Guidelines	EF	Comparability
3.C	application of 2006 IPCC Guidelines	method	Comparability
3.C	use of CH_4 default emission factor of 2006 IPCC Guidelines	EF	Comparability Transparency Accuracy
3.D	application of 2006 IPCC Guidelines	method	Comparability
3.D.a	use of N2O default emission factor (direct emission) of 2006 IPCC Guidelines	EF	Comparability
3.D.b	use of N2O default emission factor (indirect emission) of 2006 IPCC Guidelines	EF	Comparability
3.F	application of 2006 IPCC Guidelines	method	Comparability
3.F	Revision of Fraction of crop residues burnt in field Revision of Dry matter fraction Consideration of more crops	AD	Comparability Transparency Accuracy
5.A.	Application of 2006 IPCC Guidelines: FOD model	method	Accuracy, comparability
5.A.	Estimation of waste generation for the time series 1950 - 2017	AD	completeness
5.A.	Estimation of country specific waste composition	AD	Accuracy
5.A.	Application of default values of 2006 IPCC Guidelines	EF	Accuracy, comparability

9.2 Planned improvements

In the follow table the planned improvements are listed. Depending on the resources and priorities, the improvements will be implemented within the next inventory cycles.

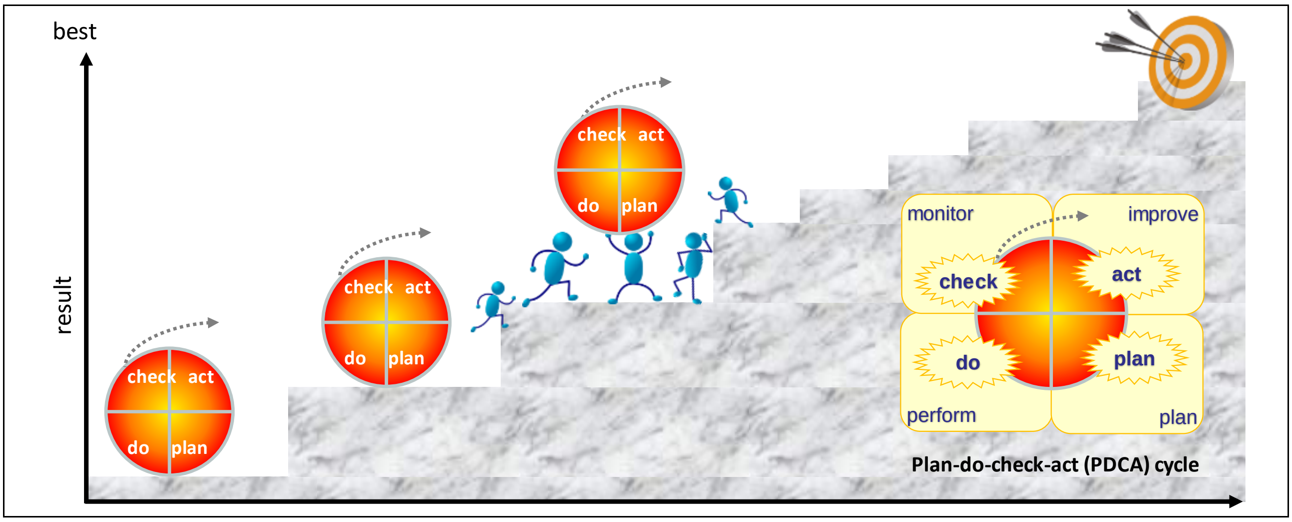


Figure 208 Continuous improvement

GHG Inventory Training ©UNEP

Table 337 Inventory Improvement plan

IPCC code	Planned improvement	Improvement	Type of improvement		Priority
1 Energy	*11.45. Regardless of the tier used, consumption of fuels by fuel/product type is the very first basic step in the estimation of CO_2 emissions from fuel combustion. If this basic step is not done properly, the subsequent steps cannot result in an accurate estimate. […] It is therefore unequivocal that the quality of GHG estimates depends critically on the quality of national energy statistics. (UNSD 2018)* (A) Preparation of an energy statistics/balance (full time series) including country specific Gross calorific values (GCV) and/or Net caloric values (NCV) according to • Guidelines for the 2017 United Nations Statistics Division (UNSD) for Annual Questionnaire on Energy Statistics[235] • International Recommendations for Energy Statistics (IRES)[236] • Application of top down and bottom up • allocation of fuel consumption according to ISIC economic activities[237] (especially manufacturing industries and construction) (B) Submission of energy statistics/balance to UNSD (Department of Economic and Social Affairs, Energy Statistics Section)	Internationally agreed • definitions & classification of energy products • definitions of energy flows Complete data set (full time series) in internationally agreed format applicable for use to for GHG inventories	AD	Transparency Accuracy Completeness Comparability Consistency	high
1 Energy	Analysis of electricity production and import electricity as well consumption by economic activities • Production by fuel type • Own consumption by public power plant and auto producer • Electricity production - Electricity supply	Complete data set (full time series) in internationally agreed format applicable for use as indicator	AD	Transparency Accuracy Completeness	medium
1 Energy	Cross-check of national and international data sources (full time series) and incorporation of feedback (on both sides) (e.g.) • Afghanistan's Statistical yearbook, online data, • United Nations Statistics Division (UNSD)238 • British geological survey (BGS) • US Geological Survey (USG) Application of the concept of Recalculation	Consistent and updated time series including historical data	AD	Transparency Accuracy Completeness Comparability Consistency	high

[235] UNSD (2019): Guidelines for the 2017 United Nations Statistics Division (UNSD) for Annual Questionnaire on Energy Statistics. New York. Available (28 April 2019) at: https://unstats.un.org/unsd/energy/quest.htm and http://unstats.un.org/unsd/energy

[236] UNSD (2018): International Recommendations for Energy Statistics (IRES). UN Department of Economic and Social Affairs. Statistics Division. Statistical Papers Series M No. 93. ST/ESA/STAT/SER.M/93. New York. Available (28 April 2019) at: https://unstats.un.org/unsd/energy/ires/IRES-web.pdf

[237] International Standard Industrial Classification of All Economic Activities (ISIC)

[238] United Nations Statistics Division (2019): Global statistical system. Available (25 May 2019) at: https://unstats.un.org/home/

IPCC code	Planned improvement	Improvement	Type of improvement		Priority
1 Energy	*10.22. Revisions are an important part of the compilation of energy statistics.[…]* *10.23. In general, two types of revisions are distinguished: (a) routine, normal or concurrent revisions […] and (b) major or special revisions […]* *10.24. With respect to routine revisions, it is recommended that countries develop a revision policy that is synchronized with the release calendar. (UNSD 2018)* Performing recalculations (revisions) in accordance with the 'UNFCCC reporting Guidelines' for NC and BUR as well as 2006 IPCC Guidelines	Recalculated emission estimates (ensuring time series consistency) including explanatory information and justifications for recalculations provided by the data provider	AD EF	Transparency Accuracy Consistency	high
1 Energy	Preparation of country specific and/or plant specific emissions factors for used fuel (national / imported) in fuel combustion • Carbon content (%) ⇒ CS $EFCO_2$ [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100) • Sulphur content (%) ⇒ **CS EF_{SO2}** [g/GJ] = (S [%] • 20000) / (NCV [GJ/t])	Country specific and/or plant specific emissions factors for key categories Input data for TIER 2 methodology	EF	Transparency Accuracy Comparability	medium
1 Energy	Information about the combustion technologies used: information about the type of combustion plant (steam generator, gas turbine, dry bottom boiler etc.) Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	Country specific and/or plant specific emissions factors for key categories	EF	Transparency Accuracy Comparability	medium
1 Energy	Data obtained from measurements made on the emission of air polluters (NON-GHG inventory) • Determination of the temperature in waste gases [°C]; • Determination of the static pressure and the dynamic pressure [kPa]; • Determination of the flow rate [m/s]; • Determination of volume flow rate [m3/h and Nm3/h]; • Determination of the concentration of CO, SO2, NOx in the exhaust gases [mg/Nm3]; and • Gravimetric extraction of solid particles (TSP) from gases and determination by applying a gravimetric method (mg/Nm^3).	country specific and/or plant specific emissions factors for key categories	EF	Transparency Accuracy Comparability	low
1 Energy	Analysis of all production processes e.g. coke oven coke production, refinery raw material as input for coke oven process; fuel type and fuel consumption for coke oven heating; use of coke oven coke gas; use of by-products like coal tar and light oils.	country specific and/or plant specific emissions factors for key categories Input data for TIER 2 methodology	AD EF	Transparency Accuracy Completeness	high
1 Energy	Analysis of charcoal production • Raw materials for carbonization. • Fuelwood & wood fuel: type of wood and wood waste • Agricultural residues • bark waste • charcoal making technologies	Complete data set of charcoal including information on parent wood density, yield of charcoal from fuelwood, net caloric value	AD EF	Transparency Accuracy Completeness	medium

IPCC code	Planned improvement	Improvement	Type of improvement		Priority
	• efficiencies of various types of kiln				
1 Energy	• Analysis of moisture content, energy values etc. of selected animal and vegetal wastes (e.g. dried cakes of animal dung) used in household for cooking and heating • Survey on amounts of used fuel based animal and vegetal wastes including generation of a historical time series • Survey on projects producing biofuels and incorporating relevant results	Complete data set of solid and gaseous biofuels based on animal and vegetal wastes	AD EF	Transparency Accuracy Completeness	medium
1 Energy 2 IPPU Chemical industry	Analysis of the Fertilizer plant • Processing and downstream units • Input data: fuel combustion and annual amount of feedstock / Total fuel requirement (GJ(NCV)/tonne NH3) • Average number of start-ups & shut-downs including maintenance period of entire/ part of the fertilizer plant • Amount CO_2 used in downstream process • Quantity of intermediate products for down stream • Quantity of final products (for sale)	Complete data regarding ammonia production including historical data set	AD EF	Transparency Accuracy Completeness	high
1 Energy Aviation	Survey on domestic and international aviation • aircraft types and fuel types • LTO by aircraft type • Origin and Destination (OD) by aircraft type • Air passengers carried • Air freight • Registered carrier departures	Complete data set including information including historical data	AD	Transparency Accuracy Completeness Comparability	high
1 Energy Aviation	Survey on full flight movements with aircraft and engine data	Complete data set including information including historical data	AD	Transparency Accuracy	medium / low
1 Energy Road transport	Survey on national / regional vehicle fleet data - Road vehicle categories, and relevant Legislation/ Technology classes • Passenger Cars • Light-Duty/Commercial Vehicles (LDV) • Heavy-Duty Vehicles (HDV) including busses and • Mopeds and Motorcycles	Complete data set including information on penetration of new technology	AD non-CO_2 EF	Transparency Accuracy Completeness Comparability Consistency	high
1 Energy Road transport	Survey on national / regional vehicle kilometer data • Annual mileage • Passenger Kilometers • Freight kilometers	Complete data set including information including historical data	AD non-CO_2 EF	Transparency Accuracy Completeness	high

IPCC code	Planned improvement	Improvement	Type of improvement		Priority
1 Energy Road transport	Estimation of CO_2 and non-CO_2 emissions as well as non-GHG emission from road transport with a tool like HBEFA[239], ARTEMIS[240], COPERT[241], MOVES[242] and PARAMICS[243] models • Estimation of emission of fuel according to energy statistics • Estimation of emission of smuggled fuels • Estimation of emissions from evaporation	emission from road transport estimated based on the transport model Country specific emissions factors for key categories	Model EF - non-CO_2 & Non-GHG	Transparency Accuracy Completeness Comparability Consistency	high
1 Energy Off-road	Survey on national / regional vehicle data – agriculture, construction, household, and relevant technology classes • Operation hours • Utilization rate	Complete data set including information on penetration of new technology	AD non-CO_2 EF	Transparency Accuracy Completeness	high
1 Energy Off-road	Estimation of CO_2 and non-CO_2 emissions as well as non-GHG emission from off-road vehicles with a tool like HBEFA[239], COPERT[241], MOVES[242] and NONROAD Model[244] models • Estimation of emission of fuel according to energy statistics • Estimation of emission of smuggled fuels • Estimation of emissions from evaporation	emission from off-road estimated based on the transport model Country specific emission factors for key categories and	Model EF - non-CO_2 & Non-GHG	Transparency Accuracy Completeness Comparability Consistency	high
1 Energy Military Multilateral operation	Survey on activities from Military and Multilateral operation • fuel combustion for producing heat and electricity from Military and Multilateral operation • fuel combustion in road transport and off-road	emission estimated from Military and Multilateral operation	AD	Transparency Accuracy Completeness	low
1 Fugitive Emissions	• Survey on underground and surface mining • Quantities of each underground and surface mining	Improvement of mining statistics including historical data (time series development)	AD	Transparency Accuracy Completeness	medium

[239] INFRAS (2019): Handbook Emission Factors for Road Transport (HBEFA): The Handbook Emission Factors for Road Transport (HBEFA) provides emission factors for all current vehicle categories (PC, LDV, HGV, urban buses, coaches and motorcycles), each divided into different categories, for a wide variety of traffic situations. Emission factors for all regulated and the most important non-regulated pollutants as well as fuel consumption and CO_2 are included. Available (25 May 2019) at: https://www.hbefa.net/e/index.html

[240] State Secretariat for Education and Research and Innovation SERI (2009): ARTEMIS: Assessment of road transport emission models and inventory systems. Bern, Swiss. Available (25 May 2019) at: https://trl.co.uk/reports/PPR350

[241] COPERT is the EU standard vehicle emissions calculator. It uses vehicle population, mileage, speed and other data such as ambient temperature and calculates emissions and energy consumption for a specific country or region. Available (25 May 2019) at: https://www.emisia.com/utilities/copert/

[242] USEPA (2018): MOtor Vehicle Emission Simulator (MOVES): EPA's MOtor Vehicle Emission Simulator (MOVES) is a state-of-the-science emission modeling system that estimates emissions for mobile sources at the national, county, and project level for criteria air pollutants, greenhouse gases, and air toxics. Available (25 May 2019) at: https://www.epa.gov/moves

[243] Paramics Microsimulation (2019): Paramics Discovery 22. Edinburgh. Available (25 May 2019) at: https://www.paramics.co.uk/en/paramics-discovery/article/paramics-discovery-22

[244] USEPA (2018): NONROAD Model (Nonroad Engines, Equipment, and Vehicles)[244]. Available (25 May 2019) at: https://www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles.

IPCC code	Planned improvement	Improvement	Type of improvement		Priority
2 IPPU Mineral industry	Survey and/or research on the annual amount of limestone and/or dolomite used in cement industry, lime industry, brick production including information of lime used in 'down-stream' processes (e.g. sugar production)	Country specific and/or plant specific emissions factors for key categories Input data for TIER 2 methodology	AD	Transparency Accuracy Completeness	high
2 IPPU Non-Energy Products from Fuels and Solvent Use	Analysis of subcategories which are occurring in Afghanistan (see Table 208) Survey on imports of Non-Energy Products from Fuels and Solvent Use in order to estimate GHG and NMVOC emissions • product type and quantities • solvent content • application conditions Investigation of data on production, import and export of the solvents and solvent containing products for the recent years and for pillar years (e.g. 1990, 1995, 2000, 2005. 2010	Improvement of statistics including historical data (time series development)	AD	Transparency Accuracy Completeness Comparability Consistency	medium
2 IPPU Product Uses as Substitutes for Ozone Depleting Substances (ODS)	Survey and/or research on import and distribution of air-conditioning (mobile /stationary) and refrigeration Sector • Preparation of an (annual) questionnaire to/for Importer, Sales and Distributors • Number of unit imports/sales in historical years / in recent years • General technical specifications of products being sold • Used cooling agent • Refrigerant distribution • Important brands / Price estimates • Countries importing from / Countries exporting to • Estimated market growth • Time used / Re-use/ Maintenance / topics of importance	Improvement of statistics regarding any cooling agent and applications including historical data (time series development) Input data (for TIER 2 methodology) Country specific emissions factors for key categories	AD	Transparency Accuracy Completeness Comparability Consistency	high
2 IPPU Product Uses as Substitutes for Ozone Depleting Substances (ODS)	In-depth analysis of (a) data on historic and current equipment (b) production, import & export of commodities of • HS code 8415 'Air-condition' • HS code 8418 'Refrigerator and freezer'	Improvement of statistics regarding any cooling agent and applications including historical data (time series development) Input data (for TIER 2 methodology) Country specific emissions factors for key categories	AD	Transparency Accuracy Completeness Comparability Consistency	high

IPCC code	Planned improvement	Improvement	Type	of improvement	Priority
2 IPPU Product Uses as Substitutes for Ozone Depleting Substances (ODS)	Investigation on applications • Polyurethane – Integral Skin / Polyurethane – Continuous Panel / Discontinuous Panel / Appliance / Injected / etc. • One Component Foam (OCF) • Extruded Polystyrene (XPS) • Phenolic – Discontinuous Block / Discontinuous Laminate Investigation of import and use of fire protection products and fire protection equipment Investigation of Domestic aerosol production / Imported aerosol production Investigation of the use and consumption (by chemical composition) of products containing HFC and/or PFC for cleaning: (i) Metered Dose Inhalers (MDIs); (ii) Personal Care Products (e.g., hair care, deodorant, shaving cream); (iii) Household Products (e.g., air-fresheners, oven and fabric cleaners); (iv) Industrial Products (e.g., special cleaning sprays such as those for operating electrical contact, lubricants, pipe-freezers); (v) Other General Products (e.g., silly string, tyre inflators, klaxons). Investigation of the use and consumption (by chemical composition) of solvents containing HFC and/or PFC products for (i) Precision Cleaning, (ii) Electronics Cleaning, (iii) Metal Cleaning, (iv) Deposition applications).		AD	Transparency Accuracy Completeness Comparability Consistency	high
2 IPPU Other Product Manufacture and Use	Survey regarding the use of • Electrical Equipment • SF6 and PFCs from Other Product Uses • N_2O from Product Uses	Improvement of statistics regarding any cooling agent and applications including historical data (time series development)	AD	Transparency Accuracy Completeness Comparability Consistency	medium
2 IPPU Other Product Manufacture and Use	Investigation of import and export data of the entire time series Investigation on specific details on the specific quantities of lubricants used as motor oils/industrial oils and as greases in order to apply TIER 2 methodology	Improvement of Energy balance and emission estimation for Non-energy use	AD	Accuracy Transparency	high
3 Agriculture Livestock	Survey and/or research on characteristics of Livestock Husbandry and Management Practice with consideration of regional and district as well urban and rural diversity • characteristics of Livestock Husbandry: breed, age distribution, weight, milk / wool yield, working hours • characteristics of Management Practice: e.g. manure system, nitrogen excretion	Improvement of agricultural statistics including historical data (time series development) Country specific emissions factors for key categories	AD EF	Transparency Accuracy Completeness Comparability Consistency	high

IPCC code	Planned improvement	Improvement	Type of improvement		Priority
		Input data for TIER 2 methodology			
3 Agriculture Rice Cultivation	Survey and/or research on characteristics of Rice Cultivation with consideration of regional and district diversity • Regional differences in rice cropping practices • Multiple crops: crop harvested on a given area of land during the year, growing conditions • Water regime: ecosystem type, flooding pattern • Organic amendments to soils • Other conditions e.g. soil type, rice cultivar	Improvement of agricultural statistics/information including historical data (time series) Country specific emissions factors for key categories Input data for TIER 2 methodology	AD EF	Transparency Accuracy Completeness Comparability Consistency	high
3 Agriculture N_2O Emissions from Managed Soils	Survey and/or research on characteristics of cultivation and soil management with consideration of regional and district as well urban and rural diversity • Type and amount of synthetic N fertilizers • Type and amount of organic N applied as fertilizer (e.g., animal manure, compost, sewage sludge, rendering waste); • Type, area and yield of crops: N in crop residues (above-ground and below-ground), including from N-fixing crops and from forages • drainage/management of organic soils	Improvement of agricultural statistics including historical data (time series development) Country specific emissions factors Input data for TIER 1 and TIER 2 methodology	AD EF	Transparency Accuracy Completeness Comparability Consistency	high
4 LULUCF General	Development a national land classification system applicable to all six land-use categories (Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land) and further subdivide by climate, soil type and/or ecological regions (i.e., strata) • land use definitions • Land cover classification, Land cover data/map covering information 20 years before 1990 or 2005 • Climate classification based on elevation, mean annual temperature, mean annual precipitation, mean annual precipitation to potential evapotranspiration ratio , and frost occurrence • ecological zones • soil classification for mineral soil types based on USDA taxonomy • area burned • information of type, age and condition of biomass	Emission and removals from LULUCF Complete data set including information including historical data Improvement of (agricultural) statistics including historical data (time series development) Country specific parameter and emissions factors Input data for TIER 1 / TIER 2 methodology	AD EF method	Transparency Accuracy Completeness Comparability Consistency	high

IPCC code	Planned improvement	Improvement	Type of improvement		Priority
4 LULUCF Forest	Survey and/or research with consideration of (a) regional and district diversity, (b) characterization by climate and/or soil type and/or (c) ecological regions (i.e., strata) • Estimates of land areas remaining forest and converted to Forest • Forest inventory and/or forest management system/Area of plantation/forests • Area annually affected by disturbances including frequency of disturbances (pest and disease outbreaks, flooding, fires, etc.). • Area annually affected by harvest (harvest categories, commercial harvest, fuelwood consumption, traditional fuelwood use and other wood use.) • Assessment of changes in carbon stock in DOM • Conversion of unmanaged to managed forest / native forest into a new forest type; • Intensification of forest management activities (i.e. site preparation, tree planting and rotation length changes; changes in harvesting practices • Harvested Wood Products: Waste deposit, sawn wood, wood panels, paper, energy purpose	Improvement of agricultural statistics including historical data (time series development) Country specific parameter and emissions factors Input data for TIER 1 / TIER 2 methodology	AD EF	Transparency Accuracy Completeness Comparability Consistency vcc	high
4 LULUCF Cropland	Survey and/or research with consideration of (a) regional and district diversity, (b) characterisation by climate and/or soil type and/or (c) ecological regions (i.e., strata) • estimates of land areas remaining cropland or converted to Cropland • information on Cropland • arable and tillable land, rice fields, and agroforestry systems • annual and perennial crops as well as temporary fallow land • crop-pasture rotation (mixed system) • land areas of growing stock and harvested land with perennial woody crops including information of Broad subcategories (i.e. fruit orchards, plantation crops, agroforestry system) and related Specific subcategories	Improvement of agricultural statistics including historical data (time series development) Country specific parameter and emissions factors Input data for TIER 1 / TIER 2 methodology	AD EF	Transparency Accuracy Completeness Comparability Consistency	high
4 LULUCF Grassland	Survey and/or research with consideration of (a) regional and district diversity, (b) characterisation by climate and/or soil type and/or (c) ecological regions (i.e., strata) • estimates of land areas remaining grassland or converted to grassland • share of land-use categories: Steppe/tundra/prairie grassland, Semi-arid grassland, Sub-tropical/ tropical grassland, Woodland/savannah, Shrubland • information on use/management systems • Area under managed organic soils	Improvement of agricultural statistics including historical data (time series development) Country specific parameter and emissions factors Input data for TIER 1 / TIER 2 methodology	AD EF	Transparency Accuracy Completeness Comparability Consistency	high

IPCC code	Planned improvement	Improvement	Type of improvement		Priority
4 LULUCF Wetland	Survey and/or research with consideration of (a) regional and district diversity, (b) characterisation by climate and/or soil type and/or (c) ecological regions (i.e., strata) • Estimates of land areas remaining wetland or converted to wetland • Wetland use, protection and wetland management • Area under managed organic soils • Peat extraction	Improvement of agricultural statistics including historical data (time series development) Country specific parameter and emissions factors Input data for TIER 1 / TIER 2 methodology	AD EF	Transparency Accuracy Completeness Comparability Consistency	high
4 LULUCF Settlements	Survey with consideration of (a) regional and district diversity, (b) characterisation by climate and/or soil type and/or (c) ecological regions (i.e., strata) estimates of land areas remaining settlement or converted to settlement information on use/management systems	Improvement of agricultural statistics including historical data (time series development) Country specific parameter and emissions factors Input data for TIER 1	AD	Transparency Accuracy Completeness Comparability Consistency	high
4 LULUCF Other land	Survey and/or research with consideration of (a) regional and district diversity, (b) characterisation by climate and/or soil type and/or (c) ecological regions (i.e., strata) • estimates of land areas remaining Other land or converted to Other Land • information on use/management system	Improvement of agricultural statistics including historical data (time series development) Country specific parameter and emissions factors Input data for TIER 1 / TIER 2 methodology	AD EF	Transparency Accuracy Completeness Comparability Consistency	high
5.A Waste Waste management	Survey and/or research of waste management practices of municipal, industrial, hazardous and clinical with consideration of consideration of regional and district as well urban and rural diversity • Waste generation rate • Composition of waste • Waste flow: collection and recycling as well as informal sector, exports • Waste management and treatment: landfill (grade of management), open burning, incineration by households and/or industries	Improvement of Waste statistics including historical data (time series development) Country specific and/or plant specific emissions factors for key categories Input data for TIER 2 methodology	AD	Transparency Accuracy Completeness Comparability Consistency	high

IPCC code	Planned improvement	Improvement	Type of improvement		Priority
5.D Waste Wastewater	Survey and/or research of wastewater treatment and management practices of municipal and industrial wastewater with consideration of regional and district as well urban and rural diversity • Wastewater generation • wastewater characterization • Wastewater flow, management and treatment	Improvement of municipal and industrial wastewater statistics including historical data (time series development) Country specific and/or plant specific emissions factors for key categories Input data for TIER 2 methodology	AD	Transparency Accuracy Completeness Comparability Consistency	High
5.D Waste Wastewater	• Annual amount of sewage sludge and N content	Amount of N applied to soil	AD	Transparency Accuracy Completeness	High

Table 338 Sector-specific planned improvements identified in regard to the National System

GHG source & sink category	Planned improvement	Improvement	Priority
Energy	*The availability of good, reliable and timely basic energy statistics and energy balances is fundamental for the estimation of GHG emissions and to address the global concerns for climate change. (UNSD 2018)* Intensive/tailor-made training for preparation of energy statistics / balances (e.g.) • in-house by UNSD, • participation in international (examples) ○ Energy Statistics Courses by International Energy Agency (IEA)[245] ○ Trainings on Energy Statistics by Joint Organizations Data Initiative (JODI) ○ Training by the South Asian Association for Regional Cooperation (SAARC) ○ participation in webinars and online training programmes	Increased capacity of involved ministries and institution including regional offices (e.g.) • Ministry of Mines and Petroleum MoMP • Ministry of Energy and Water (MEW) • National Statistics and Information Authority (NSIA) • DABS Da Afghanistan Breshna Sherkat	High
Energy - Road transport & Off-road	Intensive/tailor-made training for estimation of non-CO_2 emissions and non-GHG emissions from road transport and off-road with a tool like HBEFA, ARTEMIS, COPERT, MOVES and PARAMIX model • in-house / tailor-made training on a model for estimating emission from road transport and off-road • participation in international trainings	Increased capacity of involved ministries and institution including regional offices (e.g.) • Ministry of Transport (MoT) • Ministry of Mines and Petroleum (MoMP) • National Statistics and Information Authority (NSIA) • National Environnemental Protection Agency (NEPA)	High

[245] Available (25 February 2019) at: https://www.iea.org/statistics/?country=WORLD&year=2016&category= Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES

GHG source & sink category	Planned improvement	Improvement	Priority
IPPU - F-gases	Intensive/tailor-made training for estimation of GHG emissions from the import, use, maintenance, recycling and destruction of F-gas containing products/installations	Increased capacity of involved ministries and institution • National Environnemental Protection Agency (NEPA) • Ministry of Finance – customs • National Statistics and Information Authority (NSIA)	High
Agriculture	Intensive/tailor-made training for estimation of GHG emissions from Livestock Husbandry and Management Practice, soil cultivation	Increased capacity of involved ministries and institution • Ministry of Agriculture Irrigation and Livestock (MAIL) • National Environnemental Protection Agency (NEPA) • National Statistics and Information Authority (NSIA)	High
Training on LULUCF	Intensive/tailor-made training for estimation of GHG emissions from LULUCF • Land definition and classification • Land cover mapping • Estimation of GHG of each land use category	Increased capacity of involved ministries and institution • Ministry of Agriculture Irrigation and Livestock (MAIL) • National Environnemental Protection Agency (NEPA) • National Statistics and Information Authority (NSIA)	High
Training on Waste	Intensive/tailor-made training for estimation of GHG emissions from • Solid waste disposal • Wastewater treatment	Increased capacity of involved ministries and institution • National Environnemental Protection Agency (NEPA) • National Statistics and Information Authority (NSIA) • Ministry of Rural Rehabilitation and Development (MRRD) • Independent Directorate of Local Governance (IDLG)	High

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11 Units, abbreviations and acronyms

11.1 Units and abbreviations, and standard equivalents

Unit	Abbreviation	Equivalents	Equivalents
1 tonne of oil equivalent (toe)	1 toe	1 x 10^{10} calories	1 x 10^{10} cal
1 ktoe		41.868 terajoules	41.868 TJ
1 short ton	1 sh t	0.9072 tonne	0.9072 t
1 tonne	1 t	1.1023 short tons	1.1023 sh t
1 kilogram	1 kg	2.2046 pounds	2.2046 lb
1 hectare	1 ha	10^4 square meters	10^4 m^2
1 $calorie_{IT}$	1 cal_{IT}	4.1868 Joules	4.1868 J
1 atmosphere	1 atm	101.325 kilopascal	101.325 kPa
1 gram	1 g	0.002205 pounds	0.00205 lb
1 pound	1 lb	453.6 gram	453.6 g
1 terajoule	1 TJ	2.78 x 10^5-kiloWatt hour	2.78 x 10^5 kWh
1 kilowatt hour	1 kWh	3.6 x 10^6 Joules	3.6 x 10^6 J

Source: 2006 IPCC Guidelines, Volume 1: General Guidance and Reporting, Annex 8A.1: Prefixes, units and abbreviations, standard equivalents

11.2 Derived units

Tons			Grams			Equivalents*				
Multiple	Name	Symbol	Multiple	Name	Symbol	Tonnes (t)	Kilograms (kg)	Grams (g)	US/short tons (ST)[†]	Imperial/long tons (LT)[†]
10^0	tonne	t	10^6	megagram	Mg	1 t	1 000 kg	1 million g	1.1023 ST	0.98421 LT
10^3	kilotonne	kt	10^9	gigagram	Gg	1 000 t	1 million kg	1 billion g	1 102.3 ST	984.21 LT
10^6	megatonne	Mt	10^{12}	teragram	Tg	1 million t	1 billion kg	1 trillion g	1.1023 million ST	984,210 LT
10^9	gigatonne	Gt	10^{15}	petagram	Pg	1 billion t	1 trillion kg	1 quadrillion g	1.1023 billion ST	984.21 million LT
10^{12}	teratonne	Tt	10^{18}	exagram	Eg	1 trillion t	1 quadrillion kg	1 quintillion g	1.1023 trillion ST	984.21 billion LT
10^{15}	petatonne	Pt	10^{21}	zettagram	Zg	1 quadrillion t	1 quintillion kg	1 sextillion g	1.1023 quadrillion ST	984.21 trillion LT
10^{18}	exatonne	Et	10^{24}	yottagram	Yg	1 quintillion t	1 sextillion kg	1 septillion g	1.1023 quintillion ST	984.21 quadrillion LT

(*The equivalent units columns use the short scale large-number naming system currently used in most English-language countries, e.g. 1 billion = 1 000 million = 1 000 000 000)

Source: https://en.wikipedia.org/wiki/Tonne

11.3 Prefixes and multiplication factors

Multiplication Factor	Abbreviation	Prefix	Symbol
1 000 000 000 000 000	10^{15}	peta	P
1 000 000 000 000	10^{12}	tera	T
1 000 000 000	10^{9}	giga	G
1 000 000	10^{6}	mega	M
1 000	10^{3}	kilo	k
100	10^{2}	hecto	h
10	10^{1}	deca	da
0.1	10^{-1}	deci	d
0.01	10^{-2}	centi	c
0.001	10^{-3}	milli	m
0.000 001	10^{-6}	micro	µ

Source: 2006 IPCC Guidelines, Volume 1: General Guidance and Reporting, Annex 8A.1: Prefixes, units and abbreviations, standard equivalents

11.4 Chemical formulae

Chemical formula	Gas
C	Carbon
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
H_2	Hydrogen
H_2S	Hydrogen sulphide
N_2O	Nitrous oxide
NO_X	Nitrogen oxides
SO_x	Sulphur oxides
SO_2	Sulphur dioxide
NMVOC	Non-methane volatile organic compound
SF_6	Sulphur hexafluoride
HFC	Hydrofluorocarbons
PFC	Perfluorocarbons
NFH_3	Nitrogen trifluoride

Source: 2006 IPCC Guidelines, Volume 1: General Guidance and Reporting, Annex 8A.1: Prefixes, units and abbreviations, standard equivalents

11.5 Acronyms

ADB	Asian Development Bank
AESS	Afghanistan Energy Sector Strategy
ANDMA	Afghanistan National Disaster Management Authority
ANDS	Afghanistan National Development Strategy
ARTEMIS	Assessment and Reliability of Transport Emission Models and Inventory Systems
ASY	Afghanistan Statistical Yearbook
BGS	British Geological Survey
BUR	Biennial Update Report
CARD-F	Comprehensive Agriculture and Rural Development – Facility
CCNIS	Climate Change National Information System
CEC	Committee for Environmental Coordination
CNG	Compressed Natural Gas
CO2eq	Carbon Dioxide Equivalent
COP	Conference of Parties
COPERT	Computer Programme to Calculate Emissions from Road Transport
CSO	Central Statistics Organization
DABS	Da Afghanistan Breshna Sherkat
DOM	Dead Organic Matter
MSW	Municipal Solid Waste
EEA	EUROPEAN ENVIRONMENT AGENCY
EF	Emission Factor
EIA	Environmental Impact Assessment
EIB	European Investment Bank
FAO	Food and Agriculture Organization of the United Nations
GCV	Gross Caloric Value
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIRoA	Government of Islamic Republic of Afghanistan
GWP	Global Warming Potential
HBEFA	Handbook Emission Factors for Road Transport (model)
HDI	Human Development Index
ICIMOD	International Centre for Integrated Mountain Development
IDLG	Independent Directorate of Local Governance
IEA	International Energy Agency
INC	Initial National Communication under the UNFCCC
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Products Use
IRES	International Recommendations for Energy Statistics

IWRM	Integrated Water Resource Management
JICA	Japan International Cooperation Agency
KCA	Key Categories Analysis
kWh	Kilowatt hour
LDC	Least Developed Country
LPG	Liquid Petroleum Gas
LTO	Landing and Take-off
MAIL	Ministry of Agriculture, Irrigation and Livestock
MDG	Millennium Development Goal
MEA	Multilateral Environmental Agreement
MEW	Ministry of Energy and Water
MoEc	Ministry of Economy
MoEd	Ministry of Education
MoF	Ministry of Finance
MoFA	Ministry of Foreign Affairs
MoMP	Ministry of Mines and Petroleum
MOU	Memorandum of Understanding
MRRD	Ministry of Rehabilitation and Rural Development
MRV	Measurement Reporting and Verification
MUDL	Ministry of Urban Development and Land
MW	Mega Watt
MWh	Mega Watt hour
NAMA	Nationally Appropriate Mitigation Actions
NCCC	National Climate Change Committee
NCV	Net Caloric Value
NEPA	National Environmental Protection Agency
NGO	Non-governmental Organization
NMT	Non-Motorized Transport
Ru-WatSIP	Rural Water Supply, Sanitation and Irrigation Programme
SAARC	South Asian Association of Regional Cooperation
SEI	Stockholm Environment Institute
SNC	Second National Communication under the UNFCCC
TCCCA	Transparency, Completeness, Consistency, Comparability, Accuracy
TWG	Technical Working Group
UNDP	United Nations Development Programme
UNDESA	UN DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
UNDS	UN STATISTICS DIVISION
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency of International Development
USD	United States Dollar
USGS	United States Geological Survey
WB	World Bank

12 Annex – Reporting Tables

Notation keys	
NA	Not applicable
NO	Not occurring
NE	Not estimated
IE	Included elsewhere
C	Confidential

Annex Table 1 GHG emissions in Gg CO_2 eq – Summary for the years 1990 - 2005, 2010, 2015, 2017

Greenhouse gas source and sink categories		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2010	2015	2017
GHG (Gg CO_2 equivalent)																				
Total national GHG emissions (without LULUCF)		**18,083.25**	**16,950.69**	**15,013.80**	**15,278.60**	**15,333.75**	**15,594.85**	**17,175.07**	**18,152.90**	**18,691.28**	**18,366.46**	**15,627.54**	**14,371.22**	**18,165.04**	**20,153.14**	**20,163.62**	**22,453.86**	**36,102.42**	**41,995.19**	**43,471.39**
1	**Energy**	**5,267.65**	**4,937.88**	**3,147.85**	**3,028.04**	**2,981.32**	**2,901.09**	**3,198.22**	**3,001.22**	**2,862.16**	**2,132.09**	**2,178.63**	**2,273.73**	**2,598.96**	**3,747.32**	**4,264.20**	**5,066.98**	**13,749.13**	**19,614.68**	**21,649.43**
1.A	Fuel Combustion Activities	5,211.22	4,882.13	3,093.85	2,974.74	2,928.82	2,849.39	3,147.39	2,951.82	2,813.91	2,084.98	2,132.61	2,228.51	2,534.10	3,687.23	4,217.84	5,014.71	13,696.92	19,561.77	21,593.37
1.A.1	Energy Industries	74.65	72.51	74.84	77.78	78.02	81.54	85.29	85.99	88.78	85.80	67.30	66.27	68.51	163.56	201.06	200.44	296.63	292.41	408.05
1.A.2	Manufacturing Industries and Construction	538.80	523.54	394.30	385.40	447.17	442.18	436.76	412.12	391.90	372.31	374.35	303.95	606.37	381.97	170.16	281.90	4,372.45	4,040.48	5,962.76
1.A.3	Transport	4,190.11	3,888.31	2,268.88	2,172.52	2,076.53	1,986.77	2,264.41	2,072.57	1,932.07	1,200.97	1,289.07	1,490.10	1,439.17	2,710.72	3,370.92	4,027.38	8,094.18	13,015.30	13,136.61
1.A.4	Other Sectors	407.66	397.76	355.83	339.04	327.10	338.89	360.93	381.13	401.16	425.90	401.89	368.19	420.05	430.98	475.70	504.99	933.67	2,213.58	2,085.95
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	56.43	55.75	54.00	53.30	52.50	51.70	50.83	49.40	48.26	47.11	46.02	45.22	64.86	60.09	46.36	52.27	52.21	52.91	56.05
1.B.1	Solid Fuels	32.73	32.70	32.52	32.52	32.51	32.51	32.51	32.50	32.50	32.50	32.50	32.56	32.55	32.58	32.57	32.57	35.72	35.51	37.27
1.B.2	Oil and Natural Gas	23.70	23.05	21.48	20.79	19.99	19.18	18.33	16.90	15.75	14.61	13.52	12.66	32.32	27.52	13.79	19.70	16.49	17.40	18.78
2	**IPPU**	**248.13**	**222.62**	**202.68**	**197.96**	**121.73**	**110.00**	**95.54**	**95.54**	**95.54**	**95.54**	**58.48**	**94.09**	**98.58**	**192.65**	**146.70**	**163.84**	**231.32**	**233.87**	**245.78**
2.A	Mineral Industry	45.77	45.77	45.77	46.99	46.99	46.99	47.40	47.40	47.40	47.40	10.22	6.54	11.03	9.81	9.81	6.21	110.93	99.92	81.68
2.B	Chemical Industry	168.93	143.42	123.48	117.53	41.30	29.57	14.70	14.70	14.70	14.70	14.83	54.12	54.12	149.41	103.46	124.19	86.96	100.51	130.67
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3	**Agriculture**	**11,629.78**	**10,837.42**	**10,694.67**	**11,067.81**	**11,230.07**	**11,567.37**	**12,848.62**	**14,007.02**	**14,667.86**	**15,102.42**	**12,302.26**	**10,906.77**	**14,347.23**	**15,070.98**	**14,574.23**	**16,036.89**	**20,831.46**	**20,729.34**	**20,073.90**
3.A	Enteric Fermentation	4,976.19	4,997.17	5,046.97	5,126.89	5,315.36	5,630.95	6,548.59	7,147.83	7,545.00	8,425.41	7,097.63	5,914.00	7,638.51	7,778.74	7,514.48	7,814.80	10,650.74	10,309.18	10,273.23
3.B	Manure Management	1,947.55	1,139.45	1,135.94	1,120.26	1,159.64	1,226.12	1,414.80	1,551.40	1,645.83	1,835.42	1,547.33	1,330.38	1,580.57	1,597.09	1,557.43	1,656.99	2,317.20	2,188.64	2,183.59
3.C	Rice Cultivation	1,623.18	1,604.63	1,623.18	1,623.18	1,669.55	1,576.80	1,623.18	1,669.55	1,669.55	1,298.54	1,205.79	1,122.31	1,252.17	1,344.92	1,808.68	1,484.05	1,929.26	2,040.57	2,040.57
3.D	Agricultural soils	3,020.26	3,041.43	2,840.24	3,150.46	3,061.74	3,112.57	3,246.61	3,621.84	3,790.32	3,527.24	2,439.16	2,515.44	3,846.13	4,320.29	3,662.57	5,044.38	5,887.89	6,099.17	5,487.00
3.E	Prescribed burning of savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2010	2015	2017
		GHG (Gg CO_2 equivalent)																		
Total national GHG emissions (without LULUCF)		18,083.25	16,950.69	15,013.80	15,278.60	15,333.75	15,594.85	17,175.07	18,152.90	18,691.28	18,366.46	15,627.54	14,371.22	18,165.04	20,153.14	20,163.62	22,453.86	36,102.42	41,995.19	43,471.39
3.F	Field burning of agricultural residues	8.87	9.15	9.10	9.65	10.70	11.58	10.77	11.72	12.48	11.14	7.67	7.45	12.67	15.03	13.91	18.27	22.06	23.87	21.60
3.G	Other (Urea application)	53.73	45.60	39.25	37.38	13.08	9.34	4.67	4.67	4.67	4.67	4.67	17.19	17.19	14.90	17.15	18.40	24.32	67.92	67.92
4	LULUCF	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.A	Changes in forest and other woody biomass stocks	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.B	Forest and grassland conversion	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.C	Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.D	CO_2 emissions and removals from soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.E	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	Waste	937.70	952.78	968.60	984.79	1,000.63	1,016.40	1,032.69	1,049.12	1,065.72	1,036.42	1,088.18	1,096.63	1,120.27	1,142.19	1,178.49	1,186.15	1,290.51	1,417.30	1,502.27
5.A	Solid Waste Disposal	131.72	132.55	133.00	133.48	133.24	132.52	132.61	132.46	132.07	131.46	130.36	129.31	128.30	128.58	129.06	129.79	138.77	180.36	216.36
5.B	Biological Treatment of Solid Waste	20.27	21.10	21.97	22.88	23.81	24.79	25.40	26.04	26.69	26.26	28.06	28.53	29.01	29.49	30.65	31.11	43.06	51.76	54.13
5.C	Incineration and Open Burning of Waste	14.00	14.57	15.17	15.79	16.44	17.11	17.53	17.96	18.41	18.06	19.34	19.67	19.99	20.32	21.08	21.38	29.63	30.19	28.87
5.D	Wastewater Treatment and Discharge	771.72	784.56	798.46	812.64	827.14	841.98	857.15	872.66	888.55	860.64	910.42	919.13	942.98	963.80	997.71	1,003.87	1,079.05	1,154.99	1,202.92
6	Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Memo Items																			
	International Bunkers	19.08	19.08	19.08	19.08	15.93	15.93	15.93	15.93	15.93	15.93	15.93	15.93	15.93	25.39	31.69	31.69	31.69	31.38	31.69
1.A.3.a.i	International Aviation	19.08	19.08	19.08	19.08	15.93	15.93	15.93	15.93	15.93	15.93	15.93	15.93	15.93	25.39	31.69	31.69	31.69	31.38	31.69
1.A.3.d.i	International water-borne navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CO_2 from Biomass Combustion for Energy Production	2,648.29	2,597.81	2,518.25	2,351.30	2,238.68	2,359.50	2,619.17	2,856.65	3,050.84	3,382.56	3,091.05	2,683.40	3,248.29	3,338.11	3,334.95	3,341.17	4,295.94	4,234.56	4,230.35

Annex Table 2 GHG emissions in Gg CO_2 eq – Summary for the years 1990, 1995, 2000, 2005 - 2017

Greenhouse gas source and sink categories		1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
GHG (Gg CO_2 equivalent)																
Total national GHG emissions (without LULUCF)		**18,083.25**	**15,627.54**	**22,453.86**	**22,854.61**	**25,678.10**	**27,303.07**	**31,793.03**	**36,102.42**	**35,799.66**	**39,924.62**	**41,003.34**	**42,195.75**	**41,995.19**	**42,880.77**	**43,471.39**
1	**Energy**	**5,267.65**	**2,178.63**	**5,066.98**	**5,736.67**	**7,191.20**	**8,947.55**	**10,935.03**	**13,749.13**	**14,253.71**	**17,324.81**	**18,155.72**	**18,784.66**	**19,614.68**	**20,664.69**	**21,649.43**
1.A	Fuel Combustion Activities	5,211.22	2,132.61	5,014.71	5,684.95	7,139.77	8,895.04	10,883.98	13,696.92	14,199.83	17,270.70	18,101.34	18,732.09	19,561.77	20,609.17	21,593.37
1.A.1	Energy Industries	74.65	67.30	200.44	148.28	167.59	166.43	193.58	296.63	299.17	301.92	334.93	341.15	292.41	336.20	408.05
1.A.2	Manufacturing Industries and Construction	538.80	374.35	281.90	236.41	784.89	1,538.40	2,220.11	4,372.45	3,720.09	4,040.54	4,405.10	3,979.55	4,040.48	4,816.94	5,962.76
1.A.3	Transport	4,190.11	1,289.07	4,027.38	4,755.08	5,679.96	6,614.39	7,631.50	8,094.18	8,991.74	12,156.56	12,649.52	12,880.92	13,015.30	13,136.61	13,136.61
1.A.4	Other Sectors	407.66	401.89	504.99	545.19	507.32	575.82	838.79	933.67	1,188.83	771.67	711.79	1,530.47	2,213.58	2,319.42	2,085.95
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	56.43	46.02	52.27	51.72	51.43	52.51	51.05	52.21	53.88	54.11	54.39	52.56	52.91	55.52	56.05
1.B.1	Solid Fuels	32.73	32.50	32.57	32.58	33.03	33.59	34.08	35.72	35.20	35.43	35.80	35.47	35.51	36.20	37.27
1.B.2	Oil and Natural Gas	23.70	13.52	19.70	19.15	18.40	18.92	16.97	16.49	18.68	18.68	18.58	17.09	17.40	19.33	18.78
2	**IPPU**	**248.13**	**58.48**	**163.84**	**248.43**	**249.10**	**252.65**	**240.55**	**231.32**	**254.34**	**260.30**	**261.31**	**223.77**	**233.87**	**278.59**	**245.78**
2.A	Mineral Industry	45.77	10.22	6.21	102.54	106.99	110.89	109.26	110.93	112.48	126.82	131.18	95.66	99.92	125.82	81.68
2.B	Chemical Industry	168.93	14.83	124.19	112.46	108.68	108.33	97.86	86.96	108.42	100.04	96.70	94.67	100.51	119.33	130.67
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3	**Agriculture**	**11,629.78**	**12,302.26**	**16,036.89**	**15,674.66**	**17,022.77**	**16,863.59**	**19,353.05**	**20,831.46**	**19,980.84**	**21,006.13**	**21,227.59**	**21,800.63**	**20,729.34**	**20,490.89**	**20,073.90**
3.A	Enteric Fermentation	4,976.19	7,097.63	7,814.80	8,025.76	8,306.41	9,057.54	9,275.17	10,650.74	10,587.69	10,194.85	10,084.85	10,505.79	10,309.18	10,265.21	10,273.23
3.B	Manure Management	1,947.55	1,547.33	1,656.99	1,672.13	1,718.80	1,942.52	2,012.82	2,317.20	2,316.12	2,360.80	2,346.65	2,369.36	2,188.64	2,182.39	2,183.59
3.C	Rice Cultivation	1,623.18	1,205.79	1,484.05	1,484.05	1,576.80	1,762.31	1,855.06	1,929.26	1,947.81	1,901.44	1,901.44	2,040.57	2,040.57	2,040.57	2,040.57
3.D	Agricultural soils	3,020.26	2,439.16	5,044.38	4,456.03	5,382.31	4,068.38	6,161.44	5,887.89	5,074.30	6,466.34	6,785.64	6,790.57	6,099.17	5,911.65	5,487.00
3.E	Prescribed burning of savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories		1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
GHG (Gg CO_2 equivalent)																
Total national GHG emissions (without LULUCF)		**18,083.25**	**15,627.54**	**22,453.86**	**22,854.61**	**25,678.10**	**27,303.07**	**31,793.03**	**36,102.42**	**35,799.66**	**39,924.62**	**41,003.34**	**42,195.75**	**41,995.19**	**42,880.77**	**43,471.39**
3.F	Field burning of agricultural residues	8.87	7.67	18.27	17.15	17.77	15.78	22.73	22.06	18.30	22.48	25.19	26.43	23.87	23.16	21.60
3.G	Other (Urea application)	53.73	4.67	18.40	19.54	20.68	17.08	25.84	24.32	36.62	60.22	83.82	67.92	67.92	67.92	67.92
4	**LULUCF**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4.A	Changes in forest and other woody biomass stocks	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.B	Forest and grassland conversion	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.C	Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.D	CO_2 emissions and removals from soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.E	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	**Waste**	**937.70**	**1,088.18**	**1,186.15**	**1,194.84**	**1,215.03**	**1,239.28**	**1,264.40**	**1,290.51**	**1,310.77**	**1,333.39**	**1,358.72**	**1,386.69**	**1,417.30**	**1,446.59**	**1,502.27**
5.A	Solid Waste Disposal	131.72	130.36	129.79	130.69	132.00	133.83	136.05	138.77	141.95	147.49	155.76	166.71	180.36	197.11	216.36
5.B	Biological Treatment of Solid Waste	20.27	28.06	31.11	33.35	35.74	38.11	40.55	43.06	44.90	46.70	48.45	50.14	51.76	51.49	54.13
5.C	Incineration and Open Burning of Waste	14.00	19.34	21.38	22.91	24.58	26.21	27.90	29.63	30.05	30.33	30.46	30.41	30.19	28.76	28.87
5.D	Wastewater Treatment and Discharge	771.72	910.42	1,003.87	1,007.88	1,022.72	1,041.12	1,059.90	1,079.05	1,093.86	1,108.86	1,124.05	1,139.43	1,154.99	1,169.23	1,202.92
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items															
	International Bunkers	**19.08**	**15.93**	**31.69**	**31.69**	**31.69**	**31.69**	**31.69**	**31.69**	**31.69**	**31.69**	**31.69**	**32.01**	**31.38**	**31.69**	**31.69**
1.A.3.a.i	International Aviation	19.08	15.93	31.69	31.69	31.69	31.69	31.69	31.69	31.69	31.69	31.69	32.01	31.38	31.69	31.69
1.A.3.d.i	International water-borne navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CO_2 from Biomass Combustion for Energy Production	**2,648.29**	**3,091.05**	**3,341.17**	**3,326.77**	**3,350.35**	**3,653.77**	**3,778.08**	**4,295.94**	**4,343.47**	**4,168.42**	**4,111.53**	**4,185.72**	**4,234.56**	**4,218.94**	**4,230.35**

Annex Table 3 CO_2 emissions in Gg – Summary for the years 1990 - 2005, 2010, 2015, 2017

Greenhouse gas source and sink categories		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2010	2015	2017
CO_2 emissions (Gg)																				
Total national GHG emissions (without LULUCF)		**5,191.09**	**4,836.86**	**3,052.88**	**2,940.36**	**2,801.99**	**2,694.49**	**2,940.91**	**2,724.10**	**2,568.82**	**1,826.22**	**1,855.62**	**2,028.25**	**2,302.08**	**3,502.66**	**3,971.28**	**4,774.58**	**13,201.51**	**18,993.95**	**20,934.98**
1	**Energy**	**4,886.21**	**4,565.49**	**2,807.67**	**2,701.61**	**2,663.62**	**2,571.45**	**2,836.91**	**2,620.01**	**2,464.63**	**1,722.10**	**1,788.28**	**1,912.71**	**2,181.98**	**3,290.71**	**3,802.87**	**4,587.71**	**12,939.46**	**18,685.63**	**20,615.03**
1.A	Fuel Combustion Activities	4,870.53	4,550.29	2,793.52	2,687.92	2,650.51	2,558.88	2,824.91	2,608.97	2,454.36	1,712.60	1,779.55	1,904.55	2,160.63	3,272.58	3,793.95	4,574.83	12,929.10	18,674.95	20,603.33
1.A.1	Energy Industries	45.74	42.62	42.54	42.54	39.49	39.49	39.49	36.30	36.30	29.85	7.68	4.49	4.49	96.90	131.87	128.76	93.50	63.78	93.30
1.A.2	Manufacturing Industries and Construction	536.90	521.84	393.48	384.61	446.32	441.36	435.98	411.36	391.17	371.60	373.58	303.24	605.53	381.51	169.86	281.50	4,345.87	4,016.18	5,924.39
1.A.3	Transport	4,114.52	3,818.13	2,224.56	2,129.97	2,035.84	1,947.69	2,219.24	2,031.14	1,893.40	1,181.08	1,266.88	1,463.53	1,414.41	2,654.69	3,308.17	3,951.73	7,935.87	12,761.96	12,881.00
1.A.4	Other Sectors	173.37	167.70	132.94	130.81	128.86	130.34	130.20	130.17	133.49	130.06	131.40	133.29	136.20	139.48	184.06	212.84	553.87	1,833.02	1,704.65
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	15.67	15.20	14.15	13.69	13.11	12.57	12.00	11.04	10.27	9.50	8.74	8.16	21.35	18.13	8.92	12.88	10.36	10.68	11.71
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	15.67	15.20	14.15	13.69	13.11	12.57	12.00	11.04	10.27	9.50	8.74	8.16	21.35	18.13	8.92	12.88	10.36	10.68	11.71
2	**IPPU**	**248.13**	**222.62**	**202.68**	**197.96**	**121.73**	**110.00**	**95.54**	**95.54**	**95.54**	**95.54**	**58.48**	**94.09**	**98.58**	**192.65**	**146.70**	**163.84**	**231.32**	**233.87**	**245.78**
2.A	Mineral Industry	45.77	45.77	45.77	46.99	46.99	46.99	47.40	47.40	47.40	47.40	10.22	6.54	11.03	9.81	9.81	6.21	110.93	99.92	81.68
2.B	Chemical Industry	168.93	143.42	123.48	117.53	41.30	29.57	14.70	14.70	14.70	14.70	14.83	54.12	54.12	149.41	103.46	124.19	86.96	100.51	130.67
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3	**Agriculture**	**53.73**	**45.60**	**39.25**	**37.38**	**13.08**	**9.34**	**4.67**	**4.67**	**4.67**	**4.67**	**4.67**	**17.19**	**17.19**	**14.90**	**17.15**	**18.40**	**24.32**	**67.92**	**67.92**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B	Manure Management	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C	Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2010	2015	2017
											CO_2 emissions (Gg)									
Total national GHG emissions (without LULUCF)		**5,191.09**	**4,836.86**	**3,052.88**	**2,940.36**	**2,801.99**	**2,694.49**	**2,940.91**	**2,724.10**	**2,568.82**	**1,826.22**	**1,855.62**	**2,028.25**	**2,302.08**	**3,502.66**	**3,971.28**	**4,774.58**	**13,201.51**	**18,993.95**	**20,934.98**
3.F	Field burning of agricultural residues	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.G	Other (Urea application)	53.73	45.60	39.25	37.38	13.08	9.34	4.67	4.67	4.67	4.67	4.67	17.19	17.19	14.90	17.15	18.40	24.32	67.92	67.92
4	**LULUCF**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4.A	Changes in forest and other woody biomass stocks	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.B	Forest and grassland conversion	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.C	Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.D	CO_2 emissions and removals from soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.E	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	**Waste**	**3.03**	**3.15**	**3.28**	**3.42**	**3.56**	**3.70**	**3.79**	**3.89**	**3.98**	**3.91**	**4.19**	**4.26**	**4.33**	**4.40**	**4.56**	**4.63**	**6.41**	**6.53**	**6.25**
5.A	Solid Waste Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.B	Biological Treatment of Solid Waste	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.C	Incineration and Open Burning of Waste	3.03	3.15	3.28	3.42	3.56	3.70	3.79	3.89	3.98	3.91	4.19	4.26	4.33	4.40	4.56	4.63	6.41	6.53	6.25
5.D	Wastewater Treatment and Discharge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																			
	International Bunkers	**18.92**	**18.92**	**18.92**	**18.92**	**15.77**	**15.77**	**15.77**	**15.77**	**15.77**	**15.77**	**15.77**	**15.77**	**15.77**	**25.23**	**31.53**	**31.53**	**31.53**	**31.22**	**31.53**
1.A.3.a.i	International Aviation	18.92	18.92	18.92	18.92	15.77	15.77	15.77	15.77	15.77	15.77	15.77	15.77	15.77	25.23	31.53	31.53	31.53	31.22	31.53
1.A.3.d.i	International water-borne navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CO_2 from Biomass Combustion for Energy Production	**2,648.29**	**2,597.81**	**2,518.25**	**2,351.30**	**2,238.68**	**2,359.50**	**2,619.17**	**2,856.65**	**3,050.84**	**3,382.56**	**3,091.05**	**2,683.40**	**3,248.29**	**3,338.11**	**3,334.95**	**3,341.17**	**4,295.94**	**4,234.56**	**4,230.35**

Annex Table 4 CO_2 emissions in Gg – Summary for the years 1990, 1995, 2000, 2005 - 2017

Greenhouse gas source and sink categories		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CO_2 emissions (Gg)																	
Total national GHG emissions (without LULUCF)		5,191.09	2,694.49	1,855.62	4,774.58	5,514.59	6,944.15	8,643.45	10,542.10	13,201.51	13,722.25	16,770.99	17,604.73	18,150.92	18,993.95	20,045.39	20,934.98
1	Energy	4,886.21	2,571.45	1,788.28	4,587.71	5,241.66	6,669.05	8,368.05	10,269.67	12,939.46	13,424.79	16,443.91	17,253.01	17,852.65	18,685.63	19,692.65	20,615.03
1.A	Fuel Combustion Activities	4,870.53	2,558.88	1,779.55	4,574.83	5,229.14	6,657.27	8,356.73	10,259.29	12,929.10	13,413.00	16,432.20	17,241.72	17,842.29	18,674.95	19,680.58	20,603.33
1.A.1	Energy Industries	45.74	39.49	7.68	128.76	74.59	91.59	85.63	62.98	93.50	93.66	93.97	113.65	100.08	63.78	72.41	93.30
1.A.2	Manufacturing Industries and Construction	536.90	441.36	373.58	281.50	236.20	781.34	1,529.79	2,207.19	4,345.87	3,698.37	4,016.52	4,378.36	3,955.79	4,016.18	4,787.07	5,924.39
1.A.3	Transport	4,114.52	1,947.69	1,266.88	3,951.73	4,664.93	5,571.22	6,486.98	7,484.71	7,935.87	8,817.20	11,919.48	12,402.97	12,630.02	12,761.96	12,881.00	12,881.00
1.A.4	Other Sectors	173.37	130.34	131.40	212.84	253.42	213.11	254.34	504.40	553.87	803.76	402.23	346.74	1,156.39	1,833.02	1,940.11	1,704.65
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	15.67	12.57	8.74	12.88	12.51	11.78	11.31	10.39	10.36	11.78	11.70	11.29	10.37	10.68	12.07	11.71
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	15.67	12.57	8.74	12.88	12.51	11.78	11.31	10.39	10.36	11.78	11.70	11.29	10.37	10.68	12.07	11.71
2	IPPU	248.13	110.00	58.48	163.84	248.43	249.10	252.65	240.55	231.32	254.34	260.30	261.31	223.77	233.87	278.59	245.78
2.A	Mineral Industry	45.77	46.99	10.22	6.21	102.54	106.99	110.89	109.26	110.93	112.48	126.82	131.18	95.66	99.92	125.82	81.68
2.B	Chemical Industry	168.93	29.57	14.83	124.19	112.46	108.68	108.33	97.86	86.96	108.42	100.04	96.70	94.67	100.51	119.33	130.67
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43	33.43
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3	Agriculture	53.73	9.34	4.67	18.40	19.54	20.68	17.08	25.84	24.32	36.62	60.22	83.82	67.92	67.92	67.92	67.92
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B	Manure Management	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C	Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
									CO_2 emissions (Gg)								
Total national GHG emissions (without LULUCF)		**5,191.09**	**2,694.49**	**1,855.62**	**4,774.58**	**5,514.59**	**6,944.15**	**8,643.45**	**10,542.10**	**13,201.51**	**13,722.25**	**16,770.99**	**17,604.73**	**18,150.92**	**18,993.95**	**20,045.39**	**20,934.98**
3.F	Field burning of agricultural residues	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.G	Other (Urea application)	53.73	9.34	4.67	18.40	19.54	20.68	17.08	25.84	24.32	36.62	60.22	83.82	67.92	67.92	67.92	67.92
4	**LULUCF**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4.A	Changes in forest and other woody biomass stocks	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.B	Forest and grassland conversion	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.C	Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.D	CO_2 emissions and removals from soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.E	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	**Waste**	**3.03**	**3.70**	**4.19**	**4.63**	**4.96**	**5.32**	**5.67**	**6.04**	**6.41**	**6.50**	**6.56**	**6.59**	**6.58**	**6.53**	**6.22**	**6.25**
5.A	Solid Waste Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.B	Biological Treatment of Solid Waste	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.C	Incineration and Open Burning of Waste	3.03	3.70	4.19	4.63	4.96	5.32	5.67	6.04	6.41	6.50	6.56	6.59	6.58	6.53	6.22	6.25
5.D	Wastewater Treatment and Discharge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																
	International Bunkers	**18.92**	**15.77**	**15.77**	**31.53**	**31.53**	**31.53**	**31.53**	**31.53**	**31.53**	**31.53**	**31.53**	**31.53**	**31.85**	**31.22**	**31.53**	**31.53**
1.A.3.a.i	International Aviation	18.92	15.77	15.77	31.53	31.53	31.53	31.53	31.53	31.53	31.53	31.53	31.53	31.85	31.22	31.53	31.53
1.A.3.d.i	International water-borne navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CO_2 from Biomass Combustion for Energy Production	**2,648.29**	**2,359.50**	**3,091.05**	**3,341.17**	**3,326.77**	**3,350.35**	**3,653.77**	**3,778.08**	**4,295.94**	**4,343.47**	**4,168.42**	**4,111.53**	**4,185.72**	**4,234.56**	**4,218.94**	**4,230.35**

Annex Table 5 CH_4 emissions in Gg - Summary for the years 1990 - 2005, 2010, 2015, 2017

Greenhouse gas source and sink categories		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2010	2015	2017
CH_4 emissions (Gg)																				
Total national GHG emissions (without LULUCF)		**382.37**	**350.57**	**353.60**	**356.60**	**368.01**	**380.47**	**427.73**	**460.06**	**480.65**	**507.80**	**441.47**	**381.80**	**468.07**	**479.35**	**486.36**	**490.22**	**659.68**	**651.91**	**656.74**
1	**Energy**	**11.55**	**11.39**	**11.14**	**10.73**	**10.49**	**10.96**	**11.95**	**12.74**	**13.39**	**14.11**	**13.42**	**12.33**	**14.32**	**15.17**	**14.92**	**15.25**	**25.00**	**27.18**	**30.96**
1.A	Fuel Combustion Activities	9.92	9.77	9.54	9.14	8.91	9.40	10.40	11.21	11.87	12.61	11.93	10.85	12.58	13.49	13.42	13.68	23.32	25.49	29.18
1.A.1	Energy Industries	1.15	1.19	1.29	1.41	1.54	1.68	1.83	1.98	2.10	2.24	2.38	2.47	2.56	2.66	2.76	2.85	8.12	9.14	12.59
1.A.2	Manufacturing Industries and Construction	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.38	0.35	0.55
1.A.3	Transport	0.64	0.59	0.53	0.52	0.50	0.48	0.56	0.52	0.49	0.12	0.16	0.22	0.16	0.72	0.55	0.69	1.67	2.81	2.83
1.A.4	Other Sectors	8.10	7.96	7.71	7.21	6.87	7.23	7.99	8.70	9.27	10.25	9.38	8.15	9.84	10.11	10.11	10.13	13.15	13.19	13.21
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	1.63	1.62	1.59	1.58	1.58	1.56	1.55	1.53	1.52	1.50	1.49	1.48	1.74	1.68	1.50	1.58	1.67	1.69	1.77
1.B.1	Solid Fuels	1.31	1.31	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.43	1.42	1.49
1.B.2	Oil and Natural Gas	0.32	0.31	0.29	0.28	0.27	0.26	0.25	0.23	0.22	0.20	0.19	0.18	0.44	0.38	0.19	0.27	0.25	0.27	0.28
2	**IPPU**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3	**Agriculture**	**338.05**	**305.92**	**308.69**	**311.56**	**322.70**	**334.18**	**379.90**	**410.89**	**430.29**	**457.81**	**389.97**	**331.01**	**414.91**	**424.89**	**431.14**	**434.33**	**590.96**	**576.75**	**575.05**
3.A	Enteric Fermentation	199.05	199.89	201.88	205.08	212.61	225.24	261.94	285.91	301.80	337.02	283.91	236.56	305.54	311.15	300.58	312.59	426.03	412.37	410.93
3.B	Manure Management	73.79	41.55	41.59	41.25	42.96	45.50	52.68	57.81	61.30	68.49	57.59	49.32	58.87	59.45	57.78	61.78	87.06	82.01	81.83
3.C	Rice Cultivation	64.93	64.19	64.93	64.93	66.78	63.07	64.93	66.78	66.78	51.94	48.23	44.89	50.09	53.80	72.35	59.36	77.17	81.62	81.62
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Greenhouse gas source and sink categories		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2010	2015	2017
CH_4 emissions (Gg)																				
Total national GHG emissions (without LULUCF)		**382.37**	**350.57**	**353.60**	**356.60**	**368.01**	**380.47**	**427.73**	**460.06**	**480.65**	**507.80**	**441.47**	**381.80**	**468.07**	**479.35**	**486.36**	**490.22**	**659.68**	**651.91**	**656.74**
3.F	Field burning of agricultural residues	0.28	0.29	0.29	0.31	0.34	0.37	0.35	0.39	0.41	0.36	0.24	0.24	0.41	0.49	0.43	0.60	0.71	0.75	0.67
3.G	Other (Urea application)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	**LULUCF**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4.A	Changes in forest and other woody biomass stocks	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.B	Forest and grassland conversion	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.C	Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.D	CO_2 emissions and removals from soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.E	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	**Waste**	**32.77**	**33.26**	**33.78**	**34.31**	**34.82**	**35.33**	**35.87**	**36.42**	**36.97**	**35.87**	**38.08**	**38.46**	**38.85**	**39.30**	**40.30**	**40.64**	**43.72**	**47.97**	**50.73**
5.A	Solid Waste Disposal	5.27	5.30	5.32	5.34	5.33	5.30	5.30	5.30	5.28	5.26	5.21	5.17	5.13	5.14	5.16	5.19	5.55	7.21	8.65
5.B	Biological Treatment of Solid Waste	0.47	0.49	0.51	0.53	0.56	0.58	0.59	0.61	0.62	0.61	0.65	0.67	0.68	0.69	0.71	0.73	1.00	1.21	1.26
5.C	Incineration and Open Burning of Waste	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.08	0.08	0.07
5.D	Wastewater Treatment and Discharge	26.99	27.43	27.91	28.40	28.90	29.41	29.93	30.47	31.02	29.95	32.16	32.57	32.99	33.42	34.37	34.67	37.09	39.47	40.74
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																			
	International Bunkers	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
1.A.3.a.i	International Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.d.i	International water-borne navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CO_2 from Biomass Combustion for Energy Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Annex Table 6 CH_4 emissions in Gg - Summary for the years 1990, 1995, 2000, 2005 - 2017

Greenhouse gas source and sink categories		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CH_4 emissions (Gg)																	
Total national GHG emissions (without LULUCF)		**382.37**	**380.47**	**441.47**	**490.22**	**500.14**	**518.11**	**566.17**	**584.61**	**659.68**	**658.62**	**644.39**	**640.99**	**666.25**	**651.91**	**652.50**	**656.74**
1	**Energy**	**11.55**	**10.96**	**13.42**	**15.25**	**15.47**	**15.94**	**17.43**	**20.13**	**25.00**	**25.36**	**25.81**	**26.36**	**27.42**	**27.18**	**28.70**	**30.96**
1.A	Fuel Combustion Activities	9.92	9.40	11.93	13.68	13.90	14.35	15.79	18.50	23.32	23.68	24.12	24.63	25.73	25.49	26.96	29.18
1.A.1	Energy Industries	1.15	1.68	2.38	2.85	2.94	3.03	3.22	5.22	8.12	8.21	8.31	8.84	9.64	9.14	10.55	12.59
1.A.2	Manufacturing Industries and Construction	0.03	0.01	0.01	0.01	0.00	0.05	0.12	0.19	0.38	0.31	0.35	0.39	0.34	0.35	0.43	0.55
1.A.3	Transport	0.64	0.48	0.16	0.69	0.84	1.07	1.29	1.52	1.67	1.81	2.65	2.75	2.79	2.81	2.83	2.83
1.A.4	Other Sectors	8.10	7.23	9.38	10.13	10.11	10.20	11.14	11.58	13.15	13.34	12.81	12.66	12.97	13.19	13.15	13.21
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	1.63	1.56	1.49	1.58	1.57	1.59	1.65	1.63	1.67	1.68	1.70	1.72	1.69	1.69	1.74	1.77
1.B.1	Solid Fuels	1.31	1.30	1.30	1.30	1.30	1.32	1.34	1.36	1.43	1.41	1.42	1.43	1.42	1.42	1.45	1.49
1.B.2	Oil and Natural Gas	0.32	0.26	0.19	0.27	0.27	0.26	0.30	0.26	0.25	0.28	0.28	0.29	0.27	0.27	0.29	0.28
2	**IPPU**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3	**Agriculture**	**338.05**	**334.18**	**389.97**	**434.33**	**443.56**	**460.29**	**506.26**	**521.40**	**590.96**	**588.90**	**573.48**	**568.69**	**591.93**	**576.75**	**574.74**	**575.05**
3.A	Enteric Fermentation	199.05	225.24	283.91	312.59	321.03	332.26	362.30	371.01	426.03	423.51	407.79	403.39	420.23	412.37	410.61	410.93
3.B	Manure Management	73.79	45.50	57.59	61.78	62.62	64.36	72.98	75.45	87.06	86.90	88.90	88.44	89.24	82.01	81.79	81.83
3.C	Rice Cultivation	64.93	63.07	48.23	59.36	59.36	63.07	70.49	74.20	77.17	77.91	76.06	76.06	81.62	81.62	81.62	81.62
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Greenhouse gas source and sink categories		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CH_4 emissions (Gg)																	
Total national GHG emissions (without LULUCF)		**382.37**	**380.47**	**441.47**	**490.22**	**500.14**	**518.11**	**566.17**	**584.61**	**659.68**	**658.62**	**644.39**	**640.99**	**666.25**	**651.91**	**652.50**	**656.74**
3.F	Field burning of agricultural residues	0.28	0.37	0.24	0.60	0.55	0.60	0.49	0.74	0.71	0.58	0.73	0.80	0.84	0.75	0.73	0.67
3.G	Other (Urea application)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	**LULUCF**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4.A	Changes in forest and other woody biomass stocks	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.B	Forest and grassland conversion	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.C	Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.D	CO_2 emissions and removals from soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.E	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	**Waste**	**32.77**	**35.33**	**38.08**	**40.64**	**41.12**	**41.89**	**42.47**	**43.08**	**43.72**	**44.36**	**45.09**	**45.94**	**46.90**	**47.97**	**49.06**	**50.73**
5.A	Solid Waste Disposal	5.27	5.30	5.21	5.19	5.23	5.28	5.35	5.44	5.55	5.68	5.90	6.23	6.67	7.21	7.88	8.65
5.B	Biological Treatment of Solid Waste	0.47	0.58	0.65	0.73	0.78	0.83	0.89	0.95	1.00	1.05	1.09	1.13	1.17	1.21	1.20	1.26
5.C	Incineration and Open Burning of Waste	0.04	0.04	0.05	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07
5.D	Wastewater Treatment and Discharge	26.99	29.41	32.16	34.67	35.05	35.71	36.16	36.62	37.09	37.55	38.03	38.50	38.99	39.47	39.91	40.74
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																
	International Bunkers	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
1.A.3.a.i	International Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.d.i	International water-borne navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CO_2 from Biomass Combustion for Energy Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Annex Table 7 N_2O emissions in Gg - Summary for the years 1990 - 2005, 2010, 2015, 2017

Greenhouse gas source and sink categories		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2010	2015	2017
N2O emissions (Gg)																				
Total national GHG emissions (without LULUCF)		**11.18**	**11.24**	**10.47**	**11.49**	**11.18**	**11.37**	**11.88**	**13.18**	**13.78**	**12.90**	**9.18**	**9.39**	**13.96**	**15.66**	**13.54**	**18.20**	**21.51**	**22.50**	**20.53**
1	**Energy**	**0.31**	**0.29**	**0.21**	**0.20**	**0.19**	**0.19**	**0.21**	**0.21**	**0.21**	**0.19**	**0.18**	**0.18**	**0.20**	**0.26**	**0.30**	**0.33**	**0.62**	**0.84**	**0.87**
1.A	Fuel Combustion Activities	0.31	0.29	0.21	0.20	0.19	0.19	0.21	0.21	0.21	0.19	0.18	0.18	0.20	0.26	0.30	0.33	0.62	0.84	0.87
1.A.1	Energy Industries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2	Manufacturing Industries and Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.05	0.08
1.A.3	Transport	0.20	0.19	0.10	0.10	0.09	0.09	0.10	0.10	0.09	0.06	0.06	0.07	0.07	0.13	0.16	0.20	0.39	0.61	0.62
1.A.4	Other Sectors	0.11	0.10	0.10	0.09	0.09	0.09	0.10	0.11	0.12	0.13	0.12	0.10	0.13	0.13	0.13	0.13	0.17	0.17	0.17
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	**IPPU**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3	**Agriculture**	**10.49**	**10.55**	**9.86**	**10.88**	**10.57**	**10.75**	**11.23**	**12.52**	**13.11**	**12.26**	**8.55**	**8.77**	**13.28**	**14.88**	**12.68**	**17.32**	**20.25**	**20.95**	**18.89**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B	Manure Management	0.34	0.34	0.32	0.30	0.29	0.30	0.33	0.36	0.38	0.41	0.36	0.33	0.37	0.37	0.38	0.38	0.47	0.46	0.46
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D	Agricultural soils	10.14	10.21	9.53	10.57	10.27	10.44	10.89	12.15	12.72	11.84	8.19	8.44	12.91	14.50	12.29	16.93	19.76	20.47	18.41
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Greenhouse gas source and sink categories		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2010	2015	2017
N2O emissions (Gg)																				
Total national GHG emissions (without LULUCF)		**11.18**	**11.24**	**10.47**	**11.49**	**11.18**	**11.37**	**11.88**	**13.18**	**13.78**	**12.90**	**9.18**	**9.39**	**13.96**	**15.66**	**13.54**	**18.20**	**21.51**	**22.50**	**20.53**
3.F	Field burning of agricultural residues	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02
3.G	Other (Urea application)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	**LULUCF**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4.A	Changes in forest and other woody biomass stocks	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.B	Forest and grassland conversion	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.C	Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.D	CO_2 emissions and removals from soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.E	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	**Waste**	**0.39**	**0.40**	**0.41**	**0.41**	**0.42**	**0.43**	**0.44**	**0.45**	**0.46**	**0.46**	**0.44**	**0.44**	**0.49**	**0.52**	**0.56**	**0.56**	**0.64**	**0.71**	**0.76**
5.A	Solid Waste Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.B	Biological Treatment of Solid Waste	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.06	0.07	0.08
5.C	Incineration and Open Burning of Waste	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.07	0.07
5.D	Wastewater Treatment and Discharge	0.33	0.33	0.34	0.34	0.35	0.36	0.37	0.37	0.38	0.38	0.36	0.35	0.40	0.43	0.47	0.46	0.51	0.56	0.62
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																			
	International Bunkers	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
1.A.3.a.i	International Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.d.i	International water-borne navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CO_2 from Biomass Combustion for Energy Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Annex Table 8 N_2O emissions in Gg - Summary for the years 1990, 1995, 2000, 2005 - 2017

Greenhouse gas source and sink categories		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		N_2O emissions (Gg)															
Total national GHG emissions (without LULUCF)		**11.18**	**11.37**	**9.18**	**18.20**	**16.23**	**19.40**	**15.12**	**22.27**	**21.51**	**18.83**	**23.64**	**24.74**	**24.79**	**22.50**	**21.89**	**20.53**
1	**Energy**	0.31	0.19	0.18	0.33	0.36	0.42	0.48	0.54	0.62	0.65	0.79	0.82	0.83	0.84	0.85	0.87
1.A	Fuel Combustion Activities	0.31	0.19	0.18	0.33	0.36	0.42	0.48	0.54	0.62	0.65	0.79	0.82	0.83	0.84	0.85	0.87
1.A.1	Energy Industries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2	Manufacturing Industries and Construction	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.06	0.05	0.05	0.06	0.05	0.05	0.06	0.08
1.A.3	Transport	0.20	0.09	0.06	0.20	0.23	0.28	0.32	0.37	0.39	0.43	0.57	0.60	0.61	0.61	0.62	0.62
1.A.4	Other Sectors	0.11	0.09	0.12	0.13	0.13	0.13	0.14	0.15	0.17	0.17	0.17	0.16	0.17	0.17	0.17	0.17
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	**IPPU**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3	**Agriculture**	**10.49**	**10.75**	**8.55**	**17.32**	**15.32**	**18.44**	**14.06**	**21.12**	**20.25**	**17.52**	**22.18**	**23.24**	**23.27**	**20.95**	**20.32**	**18.89**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B	Manure Management	0.34	0.30	0.36	0.38	0.36	0.37	0.40	0.42	0.47	0.48	0.46	0.46	0.46	0.46	0.46	0.46
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D	Agricultural soils	10.14	10.44	8.19	16.93	14.95	18.06	13.65	20.68	19.76	17.03	21.70	22.77	22.79	20.47	19.84	18.41
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Greenhouse gas source and sink categories		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
N_2O emissions (Gg)																	
Total national GHG emissions (without LULUCF)		**11.18**	**11.37**	**9.18**	**18.20**	**16.23**	**19.40**	**15.12**	**22.27**	**21.51**	**18.83**	**23.64**	**24.74**	**24.79**	**22.50**	**21.89**	**20.53**
3.F	Field burning of agricultural residues	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
3.G	Other (Urea application)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	**LULUCF**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4.A	Changes in forest and other woody biomass stocks	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.B	Forest and grassland conversion	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.C	Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.D	CO_2 emissions and removals from soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.E	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	**Waste**	**0.39**	**0.43**	**0.44**	**0.56**	**0.54**	**0.55**	**0.58**	**0.61**	**0.64**	**0.66**	**0.67**	**0.68**	**0.70**	**0.71**	**0.72**	**0.76**
5.A	Solid Waste Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.B	Biological Treatment of Solid Waste	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.08
5.C	Incineration and Open Burning of Waste	0.03	0.04	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
5.D	Wastewater Treatment and Discharge	0.33	0.36	0.36	0.46	0.44	0.44	0.46	0.48	0.51	0.52	0.53	0.54	0.55	0.56	0.58	0.62
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																
	International Bunkers	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
1.A.3.a.i	International Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.d.i	International water-borne navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CO_2 from Biomass Combustion for Energy Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Annex Table 9 CH_4 emissions in CO_2 eq - Summary for the years 1990 - 2005, 2010, 2015, 2017

Greenhouse gas source and sink categories		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2010	2015	2017
		CH_4 (Gg CO_2 equivalent)																		
Total national GHG emissions (without LULUCF)		**9,559.16**	**8,764.15**	**8,840.06**	**8,915.04**	**9,200.35**	**9,511.75**	**10,693.21**	**11,501.50**	**12,016.19**	**12,694.91**	**11,036.64**	**9,544.97**	**11,701.77**	**11,983.85**	**12,158.89**	**12,255.60**	**16,491.98**	**16,297.70**	**16,418.51**
1	**Energy**	**288.73**	**284.70**	**278.45**	**268.18**	**262.22**	**274.07**	**298.72**	**318.62**	**334.66**	**352.87**	**335.57**	**308.26**	**357.91**	**379.21**	**373.02**	**381.27**	**624.96**	**679.60**	**773.94**
1.A	Fuel Combustion Activities	247.98	244.15	238.60	228.57	222.84	234.95	259.89	280.26	296.68	315.26	298.29	271.21	314.40	337.25	335.58	341.88	583.11	637.37	729.60
1.A.1	Energy Industries	28.80	29.80	32.20	35.14	38.44	41.97	45.71	49.61	52.40	55.88	59.60	61.77	64.01	66.43	68.88	71.37	202.97	228.55	314.66
1.A.2	Manufacturing Industries and Construction	0.68	0.61	0.29	0.28	0.30	0.30	0.28	0.27	0.26	0.25	0.26	0.24	0.33	0.18	0.11	0.16	9.58	8.76	13.81
1.A.3	Transport	15.98	14.85	13.29	12.91	12.41	12.05	14.05	13.00	12.19	2.92	4.01	5.45	4.04	17.98	13.83	17.15	41.71	70.29	70.76
1.A.4	Other Sectors	202.52	198.90	192.82	180.23	171.68	180.64	199.85	217.38	231.84	256.22	234.41	203.75	246.02	252.66	252.76	253.21	328.85	329.77	330.37
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	40.75	40.55	39.84	39.61	39.38	39.12	38.83	38.36	37.98	37.60	37.28	37.05	43.51	41.96	37.44	39.39	41.85	42.23	44.35
1.B.1	Solid Fuels	32.73	32.70	32.52	32.52	32.51	32.51	32.51	32.50	32.50	32.50	32.50	32.56	32.55	32.58	32.57	32.57	35.72	35.51	37.27
1.B.2	Oil and Natural Gas	8.02	7.84	7.33	7.10	6.87	6.61	6.32	5.85	5.48	5.10	4.78	4.50	10.97	9.39	4.87	6.81	6.13	6.71	7.07
2	**IPPU**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3	**Agriculture**	**8,451.27**	**7,647.97**	**7,717.15**	**7,789.12**	**8,067.54**	**8,354.38**	**9,497.62**	**10,272.36**	**10,757.25**	**11,445.36**	**9,749.19**	**8,275.18**	**10,372.68**	**10,622.13**	**10,778.45**	**10,858.27**	**14,774.10**	**14,418.77**	**14,376.29**
3.A	Enteric Fermentation	4,976.19	4,997.17	5,046.97	5,126.89	5,315.36	5,630.95	6,548.59	7,147.83	7,545.00	8,425.41	7,097.63	5,914.00	7,638.51	7,778.74	7,514.48	7,814.80	10,650.74	10,309.18	10,273.23
3.B	Manure Management	1,844.78	1,038.85	1,039.82	1,031.24	1,074.06	1,137.47	1,317.11	1,445.31	1,532.45	1,712.35	1,439.73	1,232.88	1,471.73	1,486.20	1,444.42	1,544.46	2,176.45	2,050.27	2,045.68
3.C	Rice Cultivation	1,623.18	1,604.63	1,623.18	1,623.18	1,669.55	1,576.80	1,623.18	1,669.55	1,669.55	1,298.54	1,205.79	1,122.31	1,252.17	1,344.92	1,808.68	1,484.05	1,929.26	2,040.57	2,040.57
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Greenhouse gas source and sink categories		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2010	2015	2017
CH_4 (Gg CO_2 equivalent)																				
Total national GHG emissions (without LULUCF)		**9,559.16**	**8,764.15**	**8,840.06**	**8,915.04**	**9,200.35**	**9,511.75**	**10,693.21**	**11,501.50**	**12,016.19**	**12,694.91**	**11,036.64**	**9,544.97**	**11,701.77**	**11,983.85**	**12,158.89**	**12,255.60**	**16,491.98**	**16,297.70**	**16,418.51**
3.F	Field burning of agricultural residues	7.11	7.33	7.18	7.81	8.56	9.16	8.74	9.66	10.24	9.06	6.03	6.00	10.28	12.27	10.87	14.96	17.65	18.75	16.82
3.G	Other (Urea application)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	**LULUCF**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4.A	Changes in forest and other woody biomass stocks	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.B	Forest and grassland conversion	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.C	Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.D	CO_2 emissions and removals from soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.E	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	**Waste**	**819.16**	**831.48**	**844.46**	**857.74**	**870.60**	**883.29**	**896.87**	**910.52**	**924.28**	**896.68**	**951.88**	**961.52**	**971.17**	**982.50**	**1,007.42**	**1,016.07**	**1,092.92**	**1,199.33**	**1,268.27**
5.A	Solid Waste Disposal	131.72	132.55	133.00	133.48	133.24	132.52	132.61	132.46	132.07	131.46	130.36	129.31	128.30	128.58	129.06	129.79	138.77	180.36	216.36
5.B	Biological Treatment of Solid Waste	11.82	12.30	12.81	13.34	13.88	14.45	14.81	15.18	15.56	15.31	16.36	16.63	16.91	17.19	17.87	18.14	25.11	30.18	31.56
5.C	Incineration and Open Burning of Waste	0.90	0.94	0.98	1.02	1.06	1.11	1.13	1.16	1.19	1.17	1.25	1.27	1.29	1.31	1.36	1.38	1.91	1.95	1.87
5.D	Wastewater Treatment and Discharge	674.73	685.69	697.67	709.90	722.41	735.22	748.32	761.72	775.46	748.74	803.91	814.31	824.67	835.42	859.13	866.76	927.13	986.84	1,018.49
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																			
	International Bunkers	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
1.A.3.a.i	International Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
1.A.3.d.i	International water-borne navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CO_2 from Biomass Combustion for Energy Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Annex Table 10 CH_4 emissions in CO_2 eq - Summary for the years 1990, 1995, 2000, 2005 - 2017

Greenhouse gas source and sink categories		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CH_4 (Gg CO_2 equivalent)																	
Total national GHG emissions (without LULUCF)		**9,559.16**	**9,511.75**	**11,036.64**	**12,255.60**	**12,503.53**	**12,952.82**	**14,154.21**	**14,615.20**	**16,491.98**	**16,465.48**	**16,109.71**	**16,024.83**	**16,656.36**	**16,297.70**	**16,312.58**	**16,418.51**
1	**Energy**	**288.73**	**274.07**	**335.57**	**381.27**	**386.66**	**398.48**	**435.85**	**503.23**	**624.96**	**634.09**	**645.36**	**658.94**	**685.54**	**679.60**	**717.39**	**773.94**
1.A	Fuel Combustion Activities	247.98	234.95	298.29	341.88	347.46	358.83	394.66	462.57	583.11	592.00	602.95	615.84	643.35	637.37	673.94	729.60
1.A.1	Energy Industries	28.80	41.97	59.60	71.37	73.51	75.79	80.61	130.48	202.97	205.35	207.80	221.09	240.92	228.55	263.72	314.66
1.A.2	Manufacturing Industries and Construction	0.68	0.30	0.26	0.16	0.10	1.30	3.11	4.67	9.58	7.84	8.67	9.64	8.57	8.76	10.76	13.81
1.A.3	Transport	15.98	12.05	4.01	17.15	20.99	26.66	32.32	38.00	41.71	45.34	66.35	68.72	69.70	70.29	70.76	70.76
1.A.4	Other Sectors	202.52	180.64	234.41	253.21	252.86	255.09	278.61	289.42	328.85	333.47	320.13	316.39	324.16	329.77	328.71	330.37
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	40.75	39.12	37.28	39.39	39.21	39.65	41.19	40.66	41.85	42.09	42.41	43.10	42.19	42.23	43.45	44.35
1.B.1	Solid Fuels	32.73	32.51	32.50	32.57	32.58	33.03	33.59	34.08	35.72	35.20	35.43	35.80	35.47	35.51	36.20	37.27
1.B.2	Oil and Natural Gas	8.02	6.61	4.78	6.81	6.63	6.62	7.60	6.58	6.13	6.89	6.97	7.29	6.72	6.71	7.25	7.07
2	**IPPU**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3	**Agriculture**	**8,451.27**	**8,354.38**	**9,749.19**	**10,858.27**	**11,088.95**	**11,507.15**	**12,656.53**	**13,034.94**	**14,774.10**	**14,722.48**	**14,337.03**	**14,217.32**	**14,798.25**	**14,418.77**	**14,368.56**	**14,376.29**
3.A	Enteric Fermentation	4,976.19	5,630.95	7,097.63	7,814.80	8,025.76	8,306.41	9,057.54	9,275.17	10,650.74	10,587.69	10,194.85	10,084.85	10,505.79	10,309.18	10,265.21	10,273.23
3.B	Manure Management	1,844.78	1,137.47	1,439.73	1,544.46	1,565.49	1,609.06	1,824.41	1,886.24	2,176.45	2,172.58	2,222.48	2,210.98	2,230.92	2,050.27	2,044.64	2,045.68
3.C	Rice Cultivation	1,623.18	1,576.80	1,205.79	1,484.05	1,484.05	1,576.80	1,762.31	1,855.06	1,929.26	1,947.81	1,901.44	1,901.44	2,040.57	2,040.57	2,040.57	2,040.57
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Greenhouse gas source and sink categories		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CH_4 (Gg CO_2 equivalent)																	
Total national GHG emissions (without LULUCF)		**9,559.16**	**9,511.75**	**11,036.64**	**12,255.60**	**12,503.53**	**12,952.82**	**14,154.21**	**14,615.20**	**16,491.98**	**16,465.48**	**16,109.71**	**16,024.83**	**16,656.36**	**16,297.70**	**16,312.58**	**16,418.51**
3.F	Field burning of agricultural residues	7.11	9.16	6.03	14.96	13.65	14.88	12.28	18.47	17.65	14.40	18.26	20.05	20.98	18.75	18.14	16.82
3.G	Other (Urea application)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	**LULUCF**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4.A	Changes in forest and other woody biomass stocks	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.B	Forest and grassland conversion	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.C	Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.D	CO_2 emissions and removals from soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.E	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	**Waste**	**819.16**	**883.29**	**951.88**	**1,016.07**	**1,027.92**	**1,047.19**	**1,061.83**	**1,077.04**	**1,092.92**	**1,108.90**	**1,127.32**	**1,148.57**	**1,172.56**	**1,199.33**	**1,226.62**	**1,268.27**
5.A	Solid Waste Disposal	131.72	132.52	130.36	129.79	130.69	132.00	133.83	136.05	138.77	141.95	147.49	155.76	166.71	180.36	197.11	216.36
5.B	Biological Treatment of Solid Waste	11.82	14.45	16.36	18.14	19.44	20.84	22.22	23.64	25.11	26.18	27.23	28.25	29.23	30.18	30.02	31.56
5.C	Incineration and Open Burning of Waste	0.90	1.11	1.25	1.38	1.48	1.59	1.69	1.80	1.91	1.94	1.96	1.97	1.97	1.95	1.86	1.87
5.D	Wastewater Treatment and Discharge	674.73	735.22	803.91	866.76	876.30	892.77	904.09	915.54	927.13	938.83	950.65	962.59	974.66	986.84	997.63	1,018.49
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																
	International Bunkers	**0.00**	**0.00**	**0.00**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
1.A.3.a.i	International Aviation	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1.A.3.d.i	International water-borne navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CO_2 from Biomass Combustion for Energy Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Annex Table 11 N_2O emissions in Gg CO_2 eq - Summary for the years 1990 - 2005, 2010, 2015, 2017

Greenhouse gas source and sink categories		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2010	2015	2017
N_2O emissions (Gg CO_2 equivalent)																				
Total national GHG emissions (without LULUCF)		**3333.00**	**3349.68**	**3120.86**	**3423.20**	**3331.41**	**3388.61**	**3540.95**	**3927.29**	**4106.26**	**3845.33**	**2735.28**	**2798.00**	**4161.20**	**4666.63**	**4033.45**	**5423.67**	**6408.93**	**6703.54**	**6117.89**
1	**Energy**	**92.71**	**87.69**	**61.73**	**58.25**	**55.48**	**55.57**	**62.60**	**62.59**	**62.87**	**57.12**	**54.77**	**52.75**	**59.07**	**77.40**	**88.31**	**98.00**	**184.71**	**249.45**	**260.45**
1.A	Fuel Combustion Activities	92.71	87.69	61.73	58.25	55.47	55.57	62.59	62.58	62.87	57.12	54.77	52.75	59.07	77.40	88.31	98.00	184.71	249.45	260.44
1.A.1	Energy Industries	0.11	0.10	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.07	0.02	0.01	0.01	0.23	0.32	0.31	0.15	0.07	0.10
1.A.2	Manufacturing Industries and Construction	1.22	1.10	0.53	0.51	0.54	0.53	0.50	0.49	0.48	0.46	0.50	0.47	0.51	0.28	0.19	0.24	17.00	15.53	24.56
1.A.3	Transport	59.61	55.34	31.03	29.64	28.28	27.04	31.12	28.43	26.48	16.97	18.18	21.12	20.72	38.05	48.93	58.50	116.60	183.05	184.86
1.A.4	Other Sectors	31.77	31.15	30.07	28.00	26.56	27.91	30.88	33.58	35.83	39.62	36.07	31.16	37.83	38.84	38.88	38.95	50.95	50.79	50.92
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	**IPPU**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3	**Agriculture**	**3124.78**	**3143.85**	**2938.27**	**3241.31**	**3149.45**	**3203.64**	**3346.32**	**3729.99**	**3905.94**	**3652.39**	**2548.40**	**2614.39**	**3957.35**	**4433.94**	**3778.62**	**5160.22**	**6033.04**	**6242.66**	**5629.70**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B	Manure Management	102.77	100.60	96.12	89.02	85.58	88.65	97.69	106.09	113.38	123.07	107.59	97.50	108.84	110.89	113.01	112.54	140.74	138.37	137.91
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D	Agricultural soils	3,020.26	3,041.43	2,840.24	3,150.46	3,061.74	3,112.57	3,246.61	3,621.84	3,790.32	3,527.24	2,439.16	2,515.44	3,846.13	4,320.29	3,662.57	5,044.38	5,887.89	6,099.17	5,487.00
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Greenhouse gas source and sink categories		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2010	2015	2017
N_2O emissions (Gg CO_2 equivalent)																				
Total national GHG emissions (without LULUCF)		**3333.00**	**3349.68**	**3120.86**	**3423.20**	**3331.41**	**3388.61**	**3540.95**	**3927.29**	**4106.26**	**3845.33**	**2735.28**	**2798.00**	**4161.20**	**4666.63**	**4033.45**	**5423.67**	**6408.93**	**6703.54**	**6117.89**
3.F	Field burning of agricultural residues	1.75	1.82	1.91	1.83	2.13	2.42	2.02	2.06	2.23	2.08	1.64	1.45	2.39	2.76	3.04	3.31	4.41	5.12	4.78
3.G	Other (Urea application)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	**LULUCF**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4.A	Changes in forest and other woody biomass stocks	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.B	Forest and grassland conversion	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.C	Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.D	CO_2 emissions and removals from soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.E	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	**Waste**	**115.51**	**118.14**	**120.86**	**123.63**	**126.48**	**129.40**	**132.03**	**134.71**	**137.46**	**135.83**	**132.11**	**130.86**	**144.77**	**155.29**	**166.51**	**165.45**	**191.18**	**211.44**	**227.75**
5.A	Solid Waste Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.B	Biological Treatment of Solid Waste	8.45	8.80	9.16	9.54	9.93	10.34	10.59	10.86	11.13	10.95	11.70	11.90	12.09	12.30	12.78	12.97	17.96	21.58	22.57
5.C	Incineration and Open Burning of Waste	10.07	10.48	10.91	11.36	11.82	12.30	12.60	12.91	13.24	12.98	13.91	14.14	14.37	14.61	15.16	15.37	21.30	21.70	20.75
5.D	Wastewater Treatment and Discharge	96.99	98.87	100.79	102.74	104.73	106.76	108.83	110.94	113.09	111.89	106.50	104.82	118.31	128.38	138.58	137.11	151.92	168.15	184.43
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																			
	International Bunkers	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**
1.A.3.a.i	International Aviation	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
1.A.3.d.i	International water-borne navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CO_2 from Biomass Combustion for Energy Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Annex Table 12 N_2O emissions in Gg CO_2 eq - Summary for the years 1990 - 2005, 2010, 2015, 2017

Greenhouse gas source and sink categories		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
N_2O emissions (Gg CO_2 equivalent)																	
Total national GHG emissions (without LULUCF)		**3333.00**	**3388.61**	**2735.28**	**5423.67**	**4836.49**	**5781.14**	**4505.41**	**6635.72**	**6408.93**	**5611.93**	**7043.92**	**7373.78**	**7388.47**	**6703.54**	**6522.81**	**6117.89**
1	**Energy**	**92.71**	**55.57**	**54.77**	**98.00**	**108.36**	**123.67**	**143.65**	**162.12**	**184.71**	**194.83**	**235.54**	**243.77**	**246.46**	**249.45**	**254.65**	**260.45**
1.A	Fuel Combustion Activities	92.71	55.57	54.77	98.00	108.35	123.67	143.65	162.12	184.71	194.83	235.54	243.77	246.45	249.45	254.64	260.44
1.A.1	Energy Industries	0.11	0.09	0.02	0.31	0.18	0.22	0.19	0.12	0.15	0.15	0.15	0.19	0.15	0.07	0.08	0.10
1.A.2	Manufacturing Industries and Construction	1.22	0.53	0.50	0.24	0.11	2.25	5.50	8.26	17.00	13.88	15.35	17.10	15.19	15.53	19.11	24.56
1.A.3	Transport	59.61	27.04	18.18	58.50	69.16	82.08	95.09	108.78	116.60	129.20	170.72	177.83	181.20	183.05	184.86	184.86
1.A.4	Other Sectors	31.77	27.91	36.07	38.95	38.91	39.12	42.87	44.97	50.95	51.60	49.31	48.65	49.91	50.79	50.60	50.92
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	**IPPU**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3	**Agriculture**	**3124.78**	**3203.64**	**2548.40**	**5160.22**	**4566.17**	**5494.94**	**4189.98**	**6292.28**	**6033.04**	**5221.74**	**6608.88**	**6926.45**	**6934.47**	**6242.66**	**6054.41**	**5629.70**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B	Manure Management	102.77	88.65	107.59	112.54	106.65	109.74	118.11	126.58	140.74	143.54	138.32	135.66	138.44	138.37	137.76	137.91
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D	Agricultural soils	3,020.26	3,112.57	2,439.16	5,044.38	4,456.03	5,382.31	4,068.38	6,161.44	5,887.89	5,074.30	6,466.34	6,785.64	6,790.57	6,099.17	5,911.65	5,487.00
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Greenhouse gas source and sink categories		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
N_2O emissions (Gg CO_2 equivalent)																	
Total national GHG emissions (without LULUCF)		**3333.00**	**3388.61**	**2735.28**	**5423.67**	**4836.49**	**5781.14**	**4505.41**	**6635.72**	**6408.93**	**5611.93**	**7043.92**	**7373.78**	**7388.47**	**6703.54**	**6522.81**	**6117.89**
3.F	Field burning of agricultural residues	1.75	2.42	1.64	3.31	3.50	2.89	3.50	4.26	4.41	3.90	4.22	5.15	5.45	5.12	5.01	4.78
3.G	Other (Urea application)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	**LULUCF**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4.A	Changes in forest and other woody biomass stocks	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.B	Forest and grassland conversion	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.C	Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.D	CO_2 emissions and removals from soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4.E	Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	**Waste**	**115.51**	**129.40**	**132.11**	**165.45**	**161.96**	**162.52**	**171.78**	**181.32**	**191.18**	**195.37**	**199.50**	**203.56**	**207.55**	**211.44**	**213.75**	**227.75**
5.A	Solid Waste Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.B	Biological Treatment of Solid Waste	8.45	10.34	11.70	12.97	13.91	14.90	15.89	16.91	17.96	18.72	19.47	20.20	20.91	21.58	21.47	22.57
5.C	Incineration and Open Burning of Waste	10.07	12.30	13.91	15.37	16.47	17.67	18.85	20.06	21.30	21.61	21.81	21.90	21.87	21.70	20.68	20.75
5.D	Wastewater Treatment and Discharge	96.99	106.76	106.50	137.11	131.58	129.95	137.04	144.36	151.92	155.04	158.22	161.46	164.77	168.15	171.60	184.43
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																
	International Bunkers	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**
1.A.3.a.i	International Aviation	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
1.A.3.d.i	International water-borne navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CO_2 from Biomass Combustion for Energy Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

The National GHG Inventory and National Inventory Report (NIR) 2019 of the Islamic Republic of Afghanistan gives a detailed and comprehensive description of the trend and the methodologies applied in the inventory for the greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), HFC, PFC, SF_6 and NF_3. With this report, Afghanistan complies with its reporting obligations under United Nations Framework Convention on Climate Change (UNFCCC) by providing transparent and verifiable documentation. It contains emission data by sector for the years 1990 − 2017 as well as information on emission factors, activity data and other basic data for emission calculations.

Each sectoral chapter as well cross-sectoral chapter are prepared in detail in order to support the readers/users of the NIR who are less familiar with the requirements on and preparation of the greenhouse gas inventory.

The National GHG Inventory and National Inventory Report (NIR) 2019 of the Islamic Republic of Afghanistan for the period 1990 – 2017 has been prepared already in the light of the 'Modalities, procedures and guidelines (MPGs) for the transparency framework for action and support referred to in Article 13 of the Paris Agreement' which will be in place from 2024 onwards:

- Application of 2006 IPCC Guidelines for National Greenhouse Gas Inventories;
- Preparation of the NIR according to the principles listed in section B. Guiding principles para 3:
    - (a) Building on and enhancing the transparency arrangements under the Convention, recognizing the special circumstances of the least developed countries (LDCs) and small island developing States (SIDS), and implementing the transparency framework in a facilitative, non-intrusive, non-punitive manner, respecting national sovereignty and avoiding placing undue burden on Parties;
    - (b) The importance of facilitating improved reporting and transparency over time;
    - (c) Providing flexibility to those developing country Parties that need it in the light of their capacities;
    - (d) Promoting transparency, accuracy, completeness, consistency and comparability;
    - (e) Avoiding duplication of work and undue burden on Parties and the secretariat;
    - (f) Ensuring that Parties maintain at least the frequency and quality of reporting in accordance with their respective obligations under the Convention;
    - (g) Ensuring that double counting is avoided;
    - (h) Ensuring environmental integrity.

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