NATIONAL GREENHOUSE GAS INVENTORY

REPORT OF GEORGIA

1990-2017

National Inventory Report

Under the United Nations Framework Convention on Climate Change

2021

National Greenhouse Gas Inventory
Report of GEORGIA
1990-2017

Tbilisi, 2021

The Ministry of Environmental Protection and Agriculture of Georgia has been in charge of coordinating the preparation of The National Inventory Report of GHG emissions to the UNFCCC.

The document was prepared and published with the assistance from the United Nations Development Programme (UNDP) and the Global Environmental Facility (GEF). The views expressed are those of the authors and do not necessarily reflect those of UNDP and GEF.

Authors: Tamar Aladashvili (Director of EIEC), Shalva Amiredjibi (Project Manager), Giorgi Mukhigulishvili (Team Leader, Energy Sector), Kakhaber Mdivani, Zhuzhuna Urchukhishvili, Sulkhan Suladze (Industrial Processes and Product Use Sector), Grigol Lazriev (Agriculture Sector, Waste Sector), Koba Chiburdanidze, Giorgi Kavtaradze, (LULUCF Sector), Ekaterine Durglishvili, Gogita Todradze (Uncertainty Analysis), Revaz Batonisashvili (Methodist).

.

The National Inventory Report of GHG emissions to the UNFCCC has been developed by the Ministry of Environmental Protection and Agriculture of Georgia with the funding of the Global Environmental Facility and support of the United Nations Development Programme in Georgia within the framework of the project “Development of Georgia’s Second Biennial Update Report and Fourth National Communication to the UNFCCC”.

Abbreviations and Symbols

AD – Activity Data
AWDS – Animal Waste Disposal Site
BOD – Biological Oxygen Demand
COD – Chemical Oxygen Demand
COP – Conference of Parties (of the UNFCCC)
DOC – Degradable Organic Carbon
EF – Emission Factor
EIA – Environmental Impact Assessment
FAOSTAT – Food and Agriculture Organization Statistics Office
GAM – Global Average Method
GEOSTAT – National Statistics Office of Georgia
GHG – Greenhouse Gas
GPG – Good Practice Guidelines
IEA – International Energy Agency
IPCC – Intergovernmental Panel on Climate Change
KfW – German Development Bank
LULUCF – Land Use, Land-Use Change and Forestry
MCF – Methane Correction Factor
MEPA – Ministry of Environmental Protection and Agriculture of Georgia
MSW – Municipal Solid Waste
NG – Natural Gas
NIR – National Inventory Report of GHGs emissions
NMVO – Non-Methane Volatile Organic Compounds
SNC – Second National Communication
TNC – Third National Communication
UNFCCC – United Nations Framework Convention on Climate Change

C – Carbon
CaO – Lime
CH_4 – Methane
CO – Carbon Monoxide
CO_2 – Carbon Dioxide
HFC – Hydrofluorocarbons
N_2O – Nitrous Oxide
PFC – Perfluorocarbons
SF_6 – Sulphur Hexafluoride
SO_2 – Sulphur Dioxide
Gg – Gigagram (10^9 grams=1000 ton)
hl – Hectoliter (100 Liter)
PJ – Peta Joule (10^{15} Joule)
TJ – Tera Joule (10^{12} Joule)

Content

List of Tables

List of Figures

Chapter 1. Introduction

1.1. A Description of Georgia's National Inventory Arrangements

1.1.1. Overview

Georgia joined the United Nations Framework Convention on Climate Change (UNFCCC) in 1994 and the parliament ratified the Kyoto Protocol on May 28, 1999 with the resolution N 1995. "The ultimate goal of this Convention is to achieve stabilization of greenhouse gas concentrations in the atmosphere at the level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved 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."

On June 7, 2017, Georgia ratified Paris Agreement and started preparing its Nationally Determined Contribution (NDC) document to be submitted in 2020. Simultaneously, the Ministry of Environmental Protection and Agriculture of Georgia develops "Climate Action Plan 2021-2030" with the technical assistance of GIZ which will be ready in 2020.

The ability of the International Community to achieve the set objective by reducing Greenhouse Gases (GHGs) emission, depends on the knowledge and understanding of the trends in GHG emissions. According to Article 4(1) (a) and Article 12(1) (a) of the Convention, all parties are required to provide the supreme body of the Convention – the Conference of the Parties[1] – with the information about national GHGs emissions and sources of their removal. Up to 2010[2], National Communication was the main reporting mechanism for Non-Annex 1 countries of the Convention. A decision[3] taken by the 16th Conference of the Parties held in Cancun (2010), requires all countries, starting 2014, to present a biennial independent and complete report (BUR- Biennial Update Report) including the trends of national GHG emissions.

In Georgia, the first GHG inventory was performed based on the 1980-1996 data, as a part of the preparation of the First/Initial National Communication (FNC, during 1997-1999). The Second National Communication (SNC, during 2006-2009) comprised GHG inventory data for the period of 1997-2006. The 2007-2011 GHG inventory was performed as a part of the Third National Communication (TNC, during 2012-2015). The First Biennial Update Report (FBUR, during 2015-2017) of Georgia to UNFCCC comprised GHG inventory data for the period of 2012-2013. The 2014-2015 GHG inventory was prepared as a part of the Second Biennial Update Report (SBUR, during 2018-2019). The Fourth National Communication (during 2019-2021) comprised GHG inventory data for the period of 2016-2017. In the latest national GHGs inventory the figures of the previous years were recalculated and adjusted in all the sectors, due to the use of IPCC 2006 guidelines and more reliable activity data.

The present report describes the results of the Sixth National Inventory of greenhouse gases for the period of 1990-2017. The Inventory is based on the Intergovernmental Panel on Climate Change (IPCC) Methodology that is comprised of the following key documents (hereafter jointly referred to as the IPCC methodology). These are:

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories[4] (hereafter referred to as IPCC 2006);

[1]Conference of the Parties (COP) - is the supreme decision-making body of the Convention. All States that are Parties to the Convention are represented at the COP.

[2]In 2010, 16th Conference of the Parties of the UNFCCC was held in Cancun, Mexico, where the decision was made to have separate reporting on inventories and climate change mitigation activities.

[3] 1/CP16; http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=2.

[4]IPCC 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Egleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. http://www.ipcc-nGgip.iges.or.jp/public/2006gl/index.html

- 2003 IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (hereafter referred to as IPCC GPG-LULUCF);
- Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories[5] (hereafter referred to as IPCC 1996);
- IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000)[6] (hereafter referred to as IPCC GPG).

Inventory Software Ver 2.69 (released in September 2019[7], for energy sector) and excel based worksheets (for IPPU, Agriculture, LULUCF, Waste sectors) were used for the compilation of the inventory. The inventory covers the following sectors: Energy; Industrial Processes and Product Use (IPPU); Agriculture, Forestry, and other Land Use (AFOLU, in separate chapters); and Waste.

The UN Framework Convention on Climate Change requires reporting the gases listed below:

Carbon Dioxide (CO_2);
Methane (CH_4);
Nitrous Oxide (N_2O);
Hydrofluorocarbons (HFCs);
Perfluorocarbons (PFCs);
Sulphur Hexafluoride (SF_6).

The Sixth National Inventory of Georgia reviews all the above-listed direct gases stipulated by the Convention as well as indirect greenhouse gases, such as: Nitrogen Oxides (NO_X), Carbon Monoxide (CO), Non-Methane Volatile Organic Compounds (NMVOCs) as well as Sulphur Dioxide (SO_2).

According to the UNFCCC reporting guidelines on annual inventories[8], the Global Warming Potentials (GWP) provided by the IPCC in its Second Assessment Report ("1995 IPCC GWP Values") based on the effects of GHGs over a 100-year time horizon was used for expressing GHG emissions and removals in CO_2 equivalents. The values of the GWP of greenhouse gases are shown in the Table below[9].

Table 1-1 Global Warming Potential (GWP) of Direct Greenhouse Gases

Gas	Lifetime, Years	100-years Horizon GWP	Gas	Lifetime, Years	100-years Horizon, GWP
CO_2	variable (50-200)	1	HFC-227ea	36.5	2.900
CH_4	12±3	21	HFC-236fa	209	6.300
N_2O	120	310	HFC-245ca	6.6	560
HFC:			**PFC:**		
HFC-23	264	11.700	PFC, CF_4	50000	6.500
HFC-32	5.6	650	PFC-116, C_2F_6	10000	9.200
HFC-125	32.6	2.800	PFC-218, C_3F_8	2600	7.000
HFC-134a	10.6	1.300	PFC 31-10, C_4F_{10}	2600	7.000
HFC-143a	48.3	3.800	PFC 51-14, C_6F_{14}	3200	7.400
HFC-152a	1.5	140	SF_6	3200	23.900

[5] IPCC, 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Emission Inventories. Reference manual. IPCC/OECD/IEA. IPCC WG1 Technical Support Unit, Hadley Centre, Meteorological Office, Bracknell, UK. http://www.ipcc-nGgip.iges.or.jp/public/gl/invs1.html
[6] IPCC, 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC-TSU NGGIP, Japan. http://www.ipcc-nGgip.iges.or.jp/public/gp/english/
[7] https://www.ipcc-nggip.iges.or.jp/software/index.html
[8] Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention, III B.
[9] IPCC Second Assessment - Climate Change 1995. IPCC, Geneva, Switzerland. pp 64

1.1.2. Institutional Arrangement of the National GHG Inventory

The Government of Georgia is a body accountable to the UNFCCC. The Ministry of Environmental Protection and Agriculture of Georgia elaborates and implements the policy in climate change[10]. The Department of Environment and Climate Change is a structural unit of the Ministry; the subunit of the above Department – The Climate Change Division, along with other functions, is responsible for coordination of periodic compilation of inventory report and its submission to the Convention Secretariat.

There is an independent non-commercial legal entity under public law of Georgia, the LEPL Environmental Information and Education Centre[11], in the structure of the Ministry of Environmental Protection and Agriculture. One of the functions of this Entity implies development of a unified environmental data base and support of its publicity. Furthermore, the Centre prepares National Greenhouse Gas Emissions Inventory reports with the assistance of independent international and local experts.

The present NIR has been prepared under the project: "The Fourth National Communication and Second Biennial Update Report to the UN Framework Convention on Climate Change". The Climate Change Division of the Ministry of Environmental Protection and Agriculture leads and coordinates the report development. UNDP Georgia operates as an implementing agency for the Global Environment Facility (GEF) project and assists Georgia during the whole program implementation process; it also monitors and supervises the project on behalf of the GEF. An executive council was formed at the initial phase of the project. The council consists of the representatives of the Ministry of Environmental Protection and Agriculture, the Ministry of Economy and Sustainable Development, UNDP, GIZ and Greens Movement (NGO). The council makes important decisions about the project, reviews and submits the work plans and changes in the budget; it is responsible for timely implementation of the project, as well as its quality.

There is an active cooperation on data exchange between the Ministry of Environmental Protection and Agriculture and National Statistics Office of Georgia based on the MoU singed in 2014.

[10] The resoulution of The Government of Georgia – on Approval of the Statute of Ministry of Environmental Protection and Agriculture of Georgia, N112, 6 March, 2018.

[11] www.eiec.gov.ge

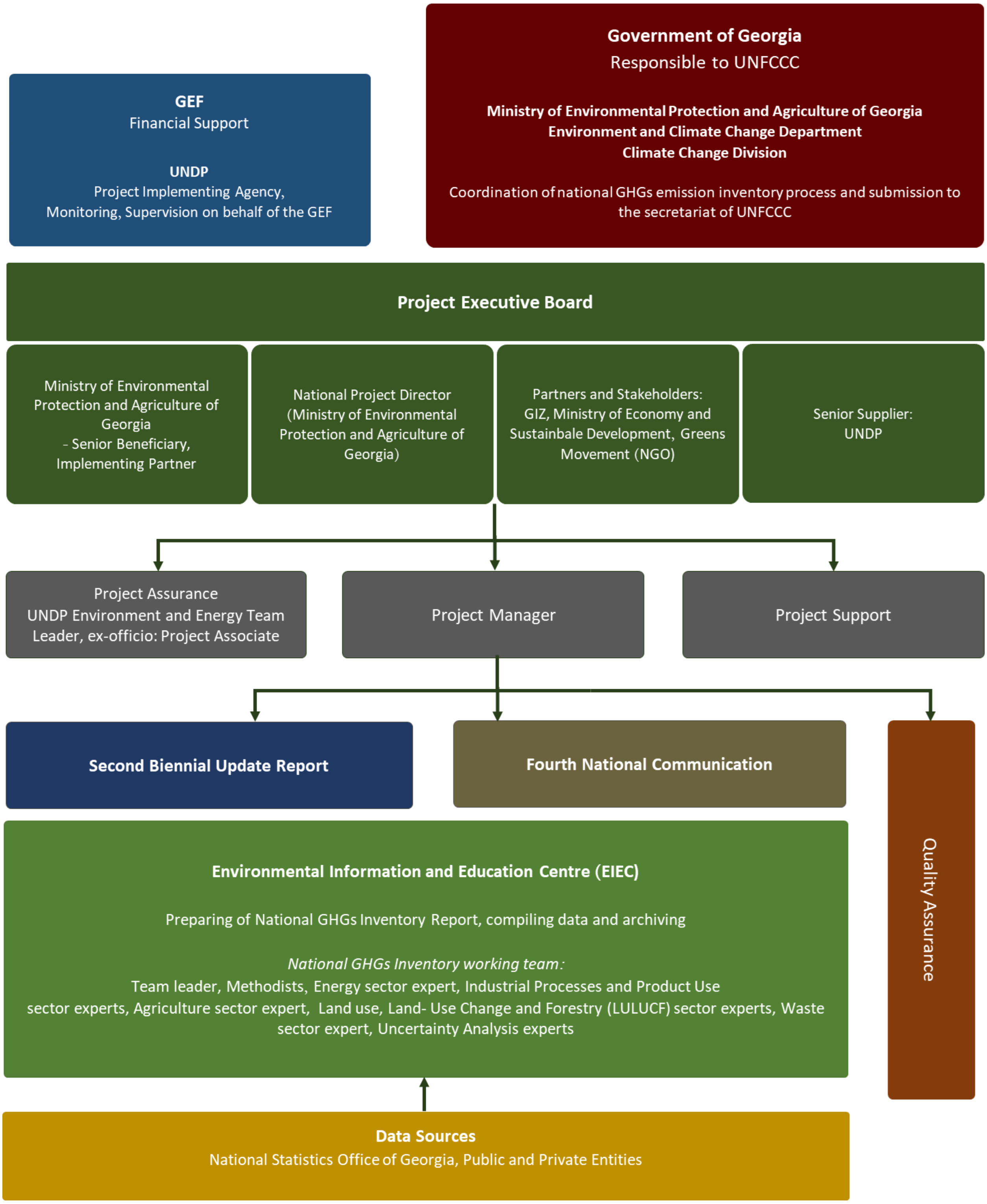


Figure 1-1 Institutional Framework of the National GHG Inventory in Georgia

1.1.3. Quality Assurance and Quality Control

The QC is carried out through a system of routine technical activities that monitor and maintain the quality of the inventory, throughout its development process. In accordance with Table 6.1, Chapter 6, Vol.1 of the 2006 IPCC Guidelines, basic QC procedures include the general items to be confirmed, related to the calculation, data processing, completeness, and documentation applicable to all emission source and sink categories. The QC activities are carried out by a team of experts involved during the preparation of the GHG NIR and by the project coordinator during the compilation and development of the GHG NIR of Georgia.

Quality Assurance (QA), as defined by the 2006 IPCC Guideline is a planned system of review procedures conducted by the personnel not directly involved in the inventory compilation/development process. Reviews, preferably by independent third parties, are performed upon completion of inventory following the QC procedures in order to verify that data quality objectives are met, ensure that the inventory represents the best possible estimates of emissions and removals given the current state of scientific knowledge and data availability, and support the effectiveness of the QC programme.

The external review of this NIR was coordinated by the UNDP-UNEP Global Support Programme (GSP) and was conducted from 16 to 22 March 2020 by Dr. Carlos Lopez, consultant in national GHG emissions inventories.

1.1.4. Treatment of the Confidential Information

Part of the AD, EFs and other parameters obtained from GEOSTAT or the private sector correspond to confidential information. These are listed and archived. At the stage of obtaining and archiving data, as well as during the QC process, confidential files are distinguished from others, and restricted access is ensured. At the stage of UN reporting, the minimum level of aggregation of the above with other sub-categories is performed, and the notation key "C" (confidential) is used.

1.2. Description of Key Categories

Chapter 4 of 2006 IPCC Guidelines for the National GHG Inventories provides rules for methodological choice and identification of key categories. According to the guideline, "a key category is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals. Whenever the term key category is used, it includes both source and sink categories."

This sub-chapter provides the analysis of key source/sink of GHG emission/removals in Georgia for the period of 1990-2017, related to absolute values of emissions/removals (level analysis), as well as for the trends, Approach 1. The key category analysis was performed using excel worksheets.

For the identification of key source/sink categories, the share of individual categories (converted to CO2 eq.) in total emissions/removals is calculated according to the absolute level of emissions/removals (level assessment). Following the calculation of contribution percentage of each source/sink category, they are summed in descending order of magnitude, adding up to 95% of the total value of all key categories.

According to the trend assessment method, a source/sink category is considered a key category if it significantly contributes to the total trend of national emissions and removals. For this assessment, the trend of a category is calculated for each source/sink category as the difference of the values of emissions/removals derived from the particular source/sink category, between current and base years for the inventory, divided by the value of current year emission/removal. Furthermore, the trend of total value of inventory is calculated by dividing the difference between the total emissions of current and base years, by current year total emission.

To assess the actual significance of the difference between the category and total trends in the outcomes of the overall inventory, these differences are weighed according to the assessment of the share of absolute value of a category of emission, i.e., a level assessment is performed. Specifically, the total emission trend is subtracted from the assessed category trend and is multiplied by the value of the level (share), obtained for this category by the "level assessment" calculated for the base year. Derived values for all categories are summed and the share of each category, as part of this total, is calculated. Thus, a key category would include a category for which the difference between the total inventory trend and the source category trend, according to the category "level" in the base year, is significant.

The current inventory was conducted for the 1990-2017 period. Hence, 1990 was considered base year for trend assessment. The derived results were arranged in a descending order and cumulative totals were calculated. The sources with the cumulative total equaling to, or higher than 95% of the overall emission (in CO_2 eq.) were determined to be a key category in terms of the trend. The identified key categories are presented in Table below.

Table 1-2 Key Categories of Georgia's GHG Inventory According to Level and Trend Assessment, Approach 1

IPCC Category code	IPCC Category	Greenhouse gas	Reasons to select as Key-category
3.B.1.a	Forest land Remaining Forest land	CO_2	Level, Trend
1.A.3.b	Road Transportation	CO_2	Level, Trend
3.B.3.a	Grassland Remaining Grassland	CO_2	Level, Trend
1.A.4	Other Sectors - Gaseous Fuels	CO_2	Level, Trend
3.B.2.a	Cropland Remaining Cropland	CO_2	Level, Trend
3.A.1	Enteric Fermentation	CH_4	Level, Trend
1.B.2.b	Natural Gas	CH_4	Level, Trend
4.A	Solid Waste Disposal	CH_4	Level, Trend
1.A.1	Energy Industries - Gaseous Fuels	CO_2	Level, Trend
3.C.4	Direct N2O Emissions from managed soils	N_2O	Level, Trend
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	Level, Trend
2.A.1	Cement production	CO_2	Level, Trend
1.A.1	Energy Industries - Solid Fuels	CO_2	Level, Trend
3.C.5	Indirect N2O Emissions from managed soils	N_2O	Level, Trend
2.C.2	Ferroalloys Production	CO_2	Level, Trend
2.B.1	Ammonia Production	CO_2	Level, Trend
4.D	Wastewater Treatment and Discharge	CH_4	Level, Trend
3.A.2	Manure Management	N_2O	Level, Trend
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	Level, Trend
2.B.2	Nitric Acid Production	N2O	Level, Trend
1.A.3.e	Other Transportation	CO_2	Level
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	Level
1.A.4	Other Sectors - Liquid Fuels	CO_2	Trend
2.C.1	Iron and Steel Production	CO_2	Trend
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	Trend
1.B.1	Solid Fuels	CH_4	Trend
1.A.1	Energy Industries - Liquid Fuels	CO_2	Trend

1.3. Uncertainty Assessment

The uncertainty analysis is one of the main activities of the inventory process. Performance of this analysis is stipulated by the Convention Reporting Guidelines and is one of the specific functions performed by the National system (Decision 20 / CP.7).

Uncertainty estimates are an essential element of a complete inventory of greenhouse gas emissions and removals. Uncertainty information is intended not for disputing the validity of the inventory estimates, but rather for supporting, prioritizing efforts to improve the accuracy of inventories and guide decisions on the methodological choice. This analysis, using appropriate analytical methods can only be carried out, for key categories.

There are two methods of uncertainty estimation stipulated by the IPCC GPG: (1) the basic method (Tier 1), which is mandatory and (2) the analytical method (Tier 2).

Tier 2 methodology is based on the Monte-Carlo analysis. The principle of the Monte-Carlo analysis is to select random values for emission factors within frames of density functions of their individual probability and calculate the corresponding emission values. This procedure is repeated several times. The results of this calculation are the probability density function of emissions values. The Monte-Carlo analysis can be performed on each source-category's level, on the level of any source-category's community, or on the total inventory's level. The Monte Carlo analysis is rather detailed one and requires considerable resources and time.

For uncertainty assessment of the Georgian inventory, the relatively simple approach of Tier 1 was applied, based on the following formulae (see annex):

- A and B show the IPCC category and greenhouse gas.
- C and D are the inventory estimates in the base year and the current year respectively, for the category and gas specified in Columns A and B, expressed in CO^2 equivalents.
- E and F contain the uncertainties for the activity data and emission factors respectively, derived from a mixture of empirical data and expert judgment as previously described in this chapter, entered as half the 95 percent confidence interval divided by the mean and expressed as a percentage. The reason for halving the 95 percent confidence interval is that the value entered in Columns E and F corresponds to the familiar plus or minus value when uncertainties are loosely quoted as 'plus or minus *x* percent', so expert judgments of this type can be directly entered in the spreadsheet. If uncertainty is known to be highly asymmetrical, the larger percentage difference between the mean and the confidence limit should be entered.
- G is the combined uncertainty by category derived from the data in Columns E and F using the error propagation equation. The entry in Column G is therefore the square root of the sum of the squares of the entries in Columns E and F.

$$G_x = \sqrt{E_x^2 + F_x^2}$$

- H shows the uncertainty in Column G as a percentage of total national emissions in the current year. The entry in each row of Column H is the square of the entry in Column G multiplied by the square of the entry in Column D, divided by the square of total at the foot of Column D. The value at the foot of Column H is an estimate of the percentage uncertainty in total national net emissions in the current year, calculated from the entries above using Equation 3.1. This total is obtained by summing the entries in Column H and taking the square root.
- Contribution to Variance by Category in Year 2017:

$$H_x = \frac{(G_x * D_x)^2}{(\sum D_i)^2}$$

Total emissions uncertainty using error propagation equation:

$$H_{tot} = \sqrt{\sum_x H_x^2}$$

Where,

X is an index that indicates the source-category,

G_x is combined uncertainty of x source-category,

E_x is activity data uncertainty of x source-category,

F_x is uncertainty of gas emission factor from x source-category,

H_x is percentage of combined uncertainty of 2017 in total emissions

D_x is emission of 2017 from x source-category,

H_{tot} is total uncertainty of emissions

In addition, the formula below **(I_x)** was used to estimate the uncertainty of the trend, which shows A type sensitivity.

I_x = percentage trend if source category x is increased by 1% in both years – percentage trend without increase

$$\frac{0.01 \bullet D_x + \sum D_i - (0.01 \bullet C_x + \sum C_i)}{(0.01 \bullet C_x + \sum C_i)} \bullet 100 - \frac{\sum D_i - \sum C_i}{\sum C_i} \bullet 100$$

This equation shows the change in emissions between the base year (1990) and the year t (2017) in response to a 1% increase in emissions of source category x emissions in the base year and year t. This shows the sensitivity of the trend in emissions to a systematic uncertainty in the emission estimate – i.e. one that is correlated between the base year and year t. This sensitivity is described as type A sensitivity.

To estimate the uncertainty of the trend, the formula presented below **(J_x),** was used, which shows B type sensitivity.

J_x = percentage trend if source category x is increased by 1% in year t – percentage trend without increase

$$J_x \frac{D_x}{\sum C_i}$$

This equation shows the changes in emissions between the base year (1990) and year t (2017) in response to a 1% increase in the emissions of source category x in the year t only. This shows the sensitivity of the trend in emissions to a random uncertainty error in the emissions estimate – i.e. one that is not correlated between the base year and year Y. This sensitivity is described as type B sensitivity.

In order to estimate the uncertainty in national emissions due to an uncertainty of emission factors (column K) the following approach, advised by the IPCC methodology, was applied:

Assuming that the same emission factor is used in both years, and that the actual emission factors are fully correlated, hence, the % error is introduced equally in both years. Therefore, the formula for the uncertainty introduced on the trend by the emission factor is:

$$K_x = \text{sensitivity A} * \text{uncertainty of emission factor} = I_x * F_x$$

In case no correlation between emission factors is assumed, sensitivity B should be used, and the K is increased by √2, for the reason given below, in the main derivation for column L:

$$K_x = \text{sensitivity B} * \text{uncertainty of emission factor} * \sqrt{2} = J_x * \mathbf{F_x} * \sqrt{\mathbf{2}}$$

To estimate uncertainty in national emissions due to uncertain activity data (column L), the following approach, according to the IPCC methodology, was used:

The trend is the difference between emissions in the base year and in the year t. Therefore, the uncertainty of the activity data of the base year and t has to be taken into account. The two uncertainties combined, using the error propagation equation and the assumption that the uncertainty is the same in the base year and year t, we use the following formula:

$$\mathrm{L_x} = \sqrt{(\text{uncertainty (activity data, base year)})^2 + (\text{uncertainty (activity data, year t)})^2}$$

$$\approx \sqrt{\text{uncertainty (activity data, year t)})^2 * 2} = \mathrm{E_x} * \sqrt{2}$$

Since activity data in both years are assumed to be independent, column L equals:

$$\mathrm{L_x} = \text{ sensitivity B} * \text{combined uncertainty of activity data of both years} = \mathrm{J_x} * \mathrm{E_x} * \sqrt{2}$$

In case correlation between activity data is assumed, sensitivity A should be used and the $\sqrt{2}$ factor does not apply:

$$\mathrm{L_x} = \mathrm{I_x} * \mathrm{E_x}$$

To estimate the uncertainty trend in national emission (column M), the following approach was used:

Column M combines the uncertainty introduced in the trend by the uncertainty in the activity data and the emission factor:

$$M_x = \sqrt{K_x^2 + L_x^2}$$

The entries Mi in column M are combined to obtain the total uncertainty of the trend, using the error propagation equation, as following:

$$M_{tot} = \sqrt{M_1^2 + M_2^2 + \cdots + M_n^2}$$

According to the general methodology, uncertainty shall be assessed on the levels of each emission subcategory and activity data, and for each emission factor. However, when the sub-categories have no correlation or interdependence between each other (for example if emission factors or activity data are the same or interdependent for different categories), it is recommended to carry out an uncertainty analysis on the aggregate level were interdependence is negligible. This approach has the advantage that the aggregated categories can be selected allowing them to match key categories analysis and, therefore, serve their purpose; it implies identification of categories (during the uncertainty assessment, as well as analysis of key categories) which requires special focus during the inventory.

Most of the countries use the aggregated categories in the uncertainty analysis, and Georgia has selected the same approach in this inventory.

The uncertainty analysis in the inventory of Georgia's National Communication is based on the Tier 1 approach and covers all source-categories and all direct greenhouse gases, where 2017 was taken for the uncertainty assessment, and 1990 as the base year. The uncertainty estimation for the activity data and emission factors was based on typical values of the IPCC and on experts' judgment. A detailed description and calculations of the uncertainty are presented in Annex B. Uncertainty Analysis.

The results revealed that the level of emissions' uncertainty (percentage uncertainty in total inventory) is within 22.85%, and the uncertainty trend – 11.99%. The highest uncertainty assessments fall on fugitive emissions from solid fuel, oil and gas extraction, also nitrous oxide emissions from civil and international aviation. Uncertainty is also relatively high in case of nitrous oxide emissions from commercial/institutional services, residential and stationary activities.

The Energy Sector

Fuel combustion (1A)

Uncertainty estimates are an essential element of a complete emission inventory. Uncertainty information is intended not for disputing the validity of the inventory estimates, but rather for supporting, prioritizing efforts to improve the accuracy of inventories and guide decisions on methodological choice.

For the fuel combustion source-category (1A) uncertainty was assessed using the Tier 1 approach, which is reviewed in detail in Annex A.

According the IPCC methodology, overall uncertainty in activity data is a combination of both systematic and random errors. Most developed countries prepare balances of fuel supply and deliveries, which provides a check on systematic errors. In these circumstances, overall systematic errors are likely to be small. Experts believe that uncertainty resulting from the two errors is probably within the range of ±5%. For countries with less well-developed energy data systems, this could be considerably larger, probably about ±10%. Informal activities may increase the uncertainty up to as much as 50% in some sectors for certain countries[12].

The uncertainty associated with EFs and NCVs results from two main elements, viz. the accuracy with which the values are measured, and the variability in the source of supply of the fuel and quality of the sampling of available supplies. There are few mechanisms to account for systematic errors in the measurement of the above properties. Consequently, it can be considered that the errors are basically random. For traded fuels, the uncertainty is likely to be less than 5%. For non-traded fuels, the uncertainty will be higher and will result, mostly, from variability in the fuel composition[13].

The IPCC typical value of uncertainty for countries with under-developed energy data systems, where there is no good practice for creation of energy balances, is 10%; in case of countries with well-developed energy data systems the uncertainty is 5%. A complete official energy balance - according to international standards and requirements - was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for the 2013 reference period). The energy balance for 1990 was also developed by Official Statistics Office, however it was mostly based on soviet standards and methodologies and was not fully in line with EU requirements. Despite this, the uncertainty was set as 5%.

According to IPCC GHG uncertainty for main activity - electricity and heat production, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is less than 1%. In case of Georgia, the uncertainty was set at 1%[14]. Uncertainty for Industrial combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 2-5%, but when data are based on extrapolation, uncertainty is about 3-10%.

The data on consumption of firewood have high level of uncertainty. The data are based on survey results of consumption of energy forms, which was conducted by the National Statistics Office of Georgia (GEOSTAT), as well as data from Georgia's Energy Balance. Compared to the 2013 inventory report, more reliable data on consumption of firewood are available, which have been collected by GEOSTAT since 2014 through household surveys and surveys in other sectors (industry, construction etc.). As mentioned above, the standard IPCC value of uncertainty for countries with under developed energy data systems, where energy balances creation is not well practiced, is 10%; in case of countries with a well-developed

[12] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (pg. 2.40)

[13] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (pg. 2.38)

[14] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (table 2.15).

energy data system, the uncertainty is 5%. Since firewood is mainly consumed by the household sector, survey respondents may assess and indicate inaccurate (approximately) volumes of consumed firewood, especially when consumed firewood is not purchased. That is why the 18.7% uncertainty value was selected.

As for emission factors, for different type of fuels, the following values of uncertainty were selected:

- for Liquid Fuels – 6.1%
- for Gaseous Fuels - 3.9
- for Solid Fuels – 12.4%
- for Biomass – 18.7%

A more detailed overview of the methods of selection of activity data for fuel combustion source category and emission factors uncertainty values is provided in chapter 3.

Fugitive emissions (1B)

In this sub-category, uncertainty assessments of activity data and emission factors were based on the expert judgments and IPCC default values[15]. Uncertainty values and their determining method are detailed in Annex B.

Industrial Processes

Cement Production (2A1)

Uncertainty estimates for cement production result predominantly from uncertainties associated with activity data, and to a lesser extent from uncertainty related to the emission factor for clinker.

The activity data is sufficiently accurate, their uncertainty is about 5%. According 2006 IPCC GHG methodology, where a clinker production data is estimated from cement production, the uncertainty of the activity data can be as high as about 35 percent. For Tier 2, the uncertainty in data on a clinker production tonnage, when available, is about 1-2 percent. Collecting data from individual producers (if complete) rather than using national totals will reduce the uncertainty of the estimate because these data will account for variations in conditions at the plant level[16].

As for the emission factor, major source of uncertainty is associated with determining the CaO content of a clinker. If a clinker data are available, the uncertainty of the emission factor is equal to the uncertainty of the CaO fraction and the assumption that it was all derived from $CaCO_3$ (Table 2.3)[17]. According to the methodology, it is assumed that the content of CaO is standard, associated with 4-8% of uncertainty. That is why, the uncertainty of emission factors is about 5%. Consequently, the combined uncertainty is 7.07%.

Lime Production (2A2)

Uncertainty estimates for lime production result predominantly from uncertainties associated with activity data, and to a lesser extent from uncertainty related to the emission factor.

The stoichiometric ratio is an exact value and, therefore, the uncertainty of the emission factor is the uncertainty of lime composition, in particular of the share of hydraulic lime that has 15% uncertainty in the

[15] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_4_Ch4_Fugitive_Emissions.pdf (table 4.2.4, table 4.2.5)

[16] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf (pg. 2.16)

[17] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf (pg. 2.17)

emission factor (2% uncertainty in the other types). Therefore, the total uncertainty is 15% at most (see Table 2.25), where default uncertainty values for lime production are given)[18].

The uncertainty for the activity data is likely to be much higher than for the emission factors, based on the experience in gathering lime data.

In Georgia, since lime production is practiced by many small enterprises, there is certain risk related to full coverage. However, the National Statistics Office of Georgia (GEOSTAT), which is the source for the above data, significantly improved data coverage in this area, but according to the IPCC methodology this uncertainty could be quite high. Consequently, based on experts' assessment, the uncertainty of activity data from this source is estimated as 20%.

Consequently, the combined uncertainty (boundaries of emission assessment) is 25% derived from the error propagation equation.

Glass production (2A3)

Glass production is estimated based on the carbonate input (Tier 3), the emission factor uncertainty (1-3 percent) is relatively low because the emission factor is based on a stoichiometric ratio[19].

Since emissions are estimated based on the quantity of melted glass in each manufacturing process and default emission factors, the uncertainty of Tier 2 is higher than Tier 3. The emission factors can be expected to have an uncertainty of +/- 10 percent.

Like cement and lime production, the uncertainty associated with weighing or proportioning of the raw materials under the Tier 3 approach is approximately 1-3 percent. Glass production data are typically measured accurately (+/-5 percent) for Tier 1 and Tier 2.

Consequently, the combined uncertainty (boundaries of emission assessment) is 11.18%, which is derived from the error propagation equation.

Ammonia Production (2B1)

According to the IPCC methodology[20], where activity data are obtained from plants, uncertainty estimates can be obtained from producers. These activity data are likely to be highly accurate (i.e., with uncertainty as low as ±2 percent). This will include uncertainty estimates for fuel use, uncertainty estimates for ammonia production and CO2 recovered. Data that are obtained from national statistical agencies usually do not include uncertainty estimates. It is good practice to consult with national statistical agencies to obtain the information on any sampling errors. In cases when national statistical agencies collect data from the ammonia production facilities, uncertainties in national statistics are not expected to differ from uncertainties established as a result of plant-level consultations. In case the uncertainty values are not available from other sources, a default value of ±5 percent can be used.

In Georgia's case, activity data were collected from the National Statistics Office of Georgia (GEOSTAT), as well as from the enterprise – Rustavi Chemical Fertilizers Plant, and are quite accurate. Emissions are calculated based on the consumed natural gas volume, as well as based on the produced ammonia amount. According to the expert judgment their uncertainty is within 5%.

[18] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf (pg. 2.25)

[19] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf (pg. 2.31)

[20] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf (pg. 3.17)

Uncertainties for the default values[21] are estimates based on data from EFMA (2000a; p.21) and de Beer, Phylipsen and Bates (2001; p.21). In general, default emission factors for gaseous inputs and outputs have higher uncertainties than those for solid or liquid inputs and outputs. Mass values for gaseous substances are influenced by temperature and pressure variations and gases tend to have higher losses through process leaks. It is a good practice to obtain uncertainty estimates at the plant level, which should be lower than uncertainty values associated with default values. Default emission factor uncertainties reflect variations between plants across different locations.

According to the new Guidelines (2006 edition), the Tier 1 approach for determining CO2 emission parameters, fuel uncertainty needed only for unit weight of the ammonia production, (which is about 6-7%), was used to estimate the coefficient. However, such an important parameter as the carbon content in natural gas, which varies according to the specific gas consumed, is crucial as well.

In the case of Georgia's energy sector, where this parameter is used, the standard value - 15.3 kg C / GJ was taken. Whereas the carbon content for specific gas is not taken into account with the ammonia coefficient, expert judgment on the overall uncertainty of CO2 emission in case of Georgia, set the coefficient at 6% or more.

Consequently, the combined uncertainty is 7.81% based on the error propagation equation.

Cast Iron and Steel Production (2C1)

According to the 2006 IPCC methodology[22] the default emission factors used for iron and steel production may have an uncertainty of ± 25 percent (see table 4.4).

In terms of uncertainty for activity data, the most important type of activity data is the amount of steel produced using each method. According to the guideline, National statistics should be available and likely have an uncertainty of ± 10 percent.

Consequently, the combined uncertainty (boundaries of emissions assessment) is 26.93% based of error propagation equation.

Time series are agreed since calculation of emissions for each year was performed using the same methodological approach and emission factors.

Ferroalloys Production (2C2)

According to the IPCC methodology, the most important type of activity data is the amount of ferroalloy production by product type and national statistics should be available and likely have an uncertainty less than 5 percent[23]. The activity data were collected from the National Statistics Office of Georgia (GEOSTAT), as well as from the Metallurgy research Institute of Georgia. Therefore, the data are rather accurate. Based on expert assessment, their uncertainty value is 5%.

Applying the Tier I approach, the uncertainty of default emission factors are evaluated within 25% range.

Consequently, the combined uncertainty (boundaries of emissions assessment) is 25.5% based on the error propagation equation.

[21] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf (table 3.1)

[22] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf (pg. 4.30)

[23] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf (pg. 4.40)

Nitric Acid Production (2B2)

According to the 2006 IPCC methodology[24], if activity data are collected from plants, uncertainty estimates can be obtained from producers. Data that are obtained from national statistical agencies usually do not include uncertainty estimates. It is a good practice to consult with national statistical agencies to get the information on any sampling errors. Whenever national statistical agencies collect data from the population of nitric acid production facilities, uncertainties in national statistics are not expected to differ from uncertainties established as a result of plant-level consultations. In case uncertainty values are not available from other sources, a default value of ±2 percent can be applied.

The data are accurate and based on expert judgment, their uncertainty does not exceed 5%.

The uncertainty of emission factor of nitrogen oxides emission for this process is high, as the real value is largely determined by parameters of the specific production. 2006 IPCC guidelines for plants with medium-pressure technology give standard limits of about 20% for uncertainty estimation[25].

Consequently, the combined uncertainty (boundaries of emissions assessment) is 20.62% based on the error propagation equation.

The time series are agreed, since calculating emissions for each year were performed using the same methodological approach and emission factors.

Agriculture

Enteric Fermentation

The activity data was obtained from the official statistical publication and is reliable. Though, classification and distribution of cattle is not entirely consistent with the IPCC standard on dairy and non-dairy cattle, but it could be assumed, that the data provided by GEOSTAT about “cows” and “other cattle” are in conformity with the classification of "dairy" and “non-dairy cattle”, as cows were intended for exactly dairy production purpose in case of Georgia, and the rest - for meat production. Therefore, the uncertainty of activity data is moderate and does not exceed 10%.

As the emission factors for the Tier 1 method are not based on country-specific data, they may not accurately represent a country’s livestock characteristics, and as a result, may be highly uncertain. Emission factors estimated using the Tier 1 method are unlikely to be known more precisely than ± 30% and may be uncertain to ± 50%. In case of Georgia uncertainty of 30% was stated; as for activity data (heads of cattle by species), they should be considered as reliable, since they are based on Official Statistical Data from GEOSTAT.

Due to the mentioned, and based on the error propagation equation, the methane emission uncertainty is about 31.62%.

Manure Management

Methane Emissions from Manure Management

Uncertainty of the data of activity related to number of the animals is assessed at 10%, since it is based on official statistical data. According to the IPCC GPG, 50% is stated for methane emission-related uncertainty. Consequently, the combined uncertainty is approximately 51%.

[24] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf (pg. 3.24)

[25] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf (table 3.3)

Nitrous oxide Emissions from Manure Management

The uncertainty of activity data for nitrous oxide emission calculation in manure management sector was estimated at 50%, as there is no accurate information about the management systems. According to the IPCC GPG, uncertainty for emission factors was estimated at 100%. Consequently, the combined uncertainty of nitrous oxide emissions is 111.8%.

Direct soil emissions

The activity data were obtained from the National Statistics Office of Georgia (GEOSTAT), which is a competent source and hence the data are quite accurate. Therefore, 10% was selected as the indicator of uncertainty.

The uncertainty for the emission coefficient was taken from the IPCC GPG standard range and was estimated based on expert assessment, which equals to 25%. Consequently, the combined uncertainty for this source-category is approximately 26.93%.

Indirect soil emissions

According to the IPCC methodology information about emission factors, leaching and volatilization fractions are sparse and highly variable. Expert judgment indicates that emission factor uncertainties are at least in order of magnitude and volatilization fraction is about +/−50%. Uncertainties in activity data estimates should be taken from the corresponding direct emissions source categories[26].

The uncertainty of activity data is also quite high and is related to the assumption of the percentage leached. In addition, the nitrogen content in fertilizers also carries uncertainty. Finally, the uncertainty of activity data was set at 50%. Consequently, the combined uncertainty is much higher (app. 71%).

Land Use Land, Use Change and Forestry (LULUCF) (CRF sector 5)

Source category: Forest land

Emission and removal factors

FAO (2006) provides uncertainty estimates for forest carbon factors; basic wood density (10 to 40%); annual increment in managed forests of industrialized countries (6%); growing stock (industrialized countries - 8%, non-industrialized countries -30%); combined natural losses for industrialized countries (15%); wood and fuel wood removals (industrialized countries - 20%).

In Finland, the uncertainty of basic wood density of pine, spruce and birch trees is under 20% in studies of Hakkila (1968, 1979). The variability between forest stands of the same species should be lower than or at most the same as for individual trees of the same species. In Finland, the uncertainty of biomass expansion factors for pine, spruce, and birch was approximately 10% (Lehtonen et al., 2003).

In eight Amazon tropical forest inventory plots, combined measurement errors led to errors of 10-30% in estimates of basal area change over periods of less than 10 years (Phillips et al., 2002)[27].

The overall uncertainty of country-specific basic wood density values should be about 20%.

[26] http://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf (pg.4.75)

[27] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf (4.19)

Activity data

According to the IPCC methodology, area data should be obtained using the guidance provided under Chapter 3 or from FAO (2000). Industrialized countries set an uncertainty in forest area estimates as approximately 3% (FAO, 2000)[28].

In Georgia's case 5% uncertainty was selected.

Cropland

The sources of uncertainty when using the Tier 1 method include the degree of accuracy in land area estimates and in the default biomass carbon increment and loss rates. Uncertainty is likely to be low (<10%) for estimates of area under different cropping systems since most countries annually estimate cropland area using reliable methods. A published compilation of research on carbon stocks in agroforestry systems was used to derive the default data provided in Table 5.1 (Schroeder, 1994). While defaults were derived from multiple studies, their associated uncertainty ranges were not included in the publication. Therefore, a default uncertainty level of +75% of the parameter value has been set based on IPCC methodology and the expert judgment[29].

Grassland

Area data and estimates of uncertainty should be obtained using the methods provided under Chapter 3. Tiers 2 and 3 approaches may also use finer resolution activity data, such as area estimates for different climatic regions or for grassland management systems within national boundaries. The finer-resolution data will reduce uncertainty levels when associated with carbon accumulation factors defined for those finer-scale land databases. If using aggregate land-use area statistics for activity data (e.g., FAO data), the inventory agency may have to apply a default level of uncertainty for the land area estimates (±50%). However, it is a good practice for the inventory compiler to derive uncertainties from country-specific activity data rather than using a default level. Therefore, in case of Georgia, activity data is quite accurate and is based on the expert assessment; its uncertainty value is within 10%.

In terms of uncertainty of emission factors, according to the IPCC methodology[30] and based on the expert judgment, a default uncertainty value of 75% was selected.

Waste

Solid Waste Disposal

The uncertainty in waste disposal data depends on the way the data is obtained. Uncertainty can be reduced when the amounts of waste in the SWDS are weighed. If the estimates are based on waste delivery vehicle capacity or visual estimation, uncertainty will be higher. Estimates based on default activity data will have the highest uncertainties.

If waste scavenging takes place at the SWDS, it needs to be taken into account while operating with the waste disposal data, otherwise, the uncertainty in waste disposal data will increase. Scavenging will also increase uncertainties in the composition of waste disposed in the SWDS, and hence also in the total DOC in the waste.

---

[28] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf (4.20)

[29] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_05_Ch5_Cropland.pdf

[30] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_06_Ch6_Grassland.pdf

Uncertainty estimates for Total Municipal Solid Waste (MSW_T) and Fraction of MSW sent to SWDS (MSW_F), as well as the default model parameters are given in Table 3.5[31]. The estimates are based on the expert judgment.

According to the IPCC methodology, the uncertainty range for Total Municipal Solid Waste (MSWT) is Country-specific: 30% is a typical value for countries which collect waste generation data on regular basis; ±10% for countries with high quality data (e.g., weighing at all SWDS and other treatment facilities). For countries with poor quality data: more than a factor of two.

Total uncertainty range of Waste composition is between ±10% for countries with high quality data (e.g., regular sampling at representative SWDS). ±30% for countries with country-specific data based on studies including periodic sampling. For countries with poor quality data: more than a factor of two[32].

Finally, for the value of uncertainty for emission factor 30% was chosen.

Industrial Wastewater handling

The activity data for industrial wastewater is the amount of manufactured produce and the volume of wastewater consumed for manufacturing the produce. According to the expert's judgment and the IPCC Guidelines, the uncertainty limits for them are estimated as following[33]:

- For Industrial Production - 25% (uncertainty limits should be discussed within the recommended limits, according IPCC, as statistical data related this sector is good quality)
- The uncertainty of industrial wastewater volume (Wastewater/unit production) according to the experts' estimation is no less than 50%
- For COD (chemical oxygen demand) concentration (COD/unit wastewater) - no less than 50%.

According IPCC 2006 guideline, these data can be very uncertain as the same sector might use different waste handling procedures at different plants and in different countries. The product of the parameters (W•COD) is expected to have less uncertainty. An uncertainty value can be attributed directly to kg COD/tonne of product. –50 %, +100% is suggested.

The combined uncertainty of this source-category, based on uncertainties of emission factors and activity data, equals to 58.31%.

Domestic Wastewater handling

The data of domestic and commercial wastewater (Domestic Wastewater handling) includes the number of the population and the share of anaerobic treated wastewater. The uncertainty of standard limits of all values are based on the experts' judgments and the 2006 IPCC methodology[34].

IPCC methodology provides default uncertainty ranges for emission factor and activity data of domestic wastewater. According to the guideline, for identifying emission factor uncertainty, uncertainty range for maximum CH4 producing capacity (Bo) is ± 30%. Consequently, the final uncertainty of emission factors was set at 30%.

[31] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf (pg. 3.27)

[32] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf (pg. 3.27)

[33] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf (ph. 6.23)

[34] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf (pg. 6.16)

According to the IPCC methodology[35]:

- Uncertainty for the human population is within 5% limit
- For BOD per person ± 30%
- For fraction of the population income group, when good quality data on urbanization are available however, the distinction between urban high income and urban low income may have to be based on the expert judgment - ± 15%.

The only national value for the emission calculation formula is the number of the populations, for which the uncertainty is estimated within 5% limits and, consequently, emission uncertainty estimation from this source is based on the standard factor evaluation given in the 2006 IPCC methodology.

Large uncertainties are associated with the IPCC default emission factors for N_2O from effluent. Currently available field data is insufficient to improve this factor. In addition, the N_2O emission factor for plants is uncertain because it is based on one field test[36].

These ranges of activity data and emission uncertainty factor are used to calculate the total uncertainty in methane and nitrous oxide emissions, which makes 58.31% for industrial waste water and 30.41% for domestic waste water; IPCC methodology includes uncertainty ranges based on the expert judgment.

Tables of Uncertainty Analysis and Uncertainty values of Activity Data and Emission Factors are provided in annex B.

Chapter 2. Trends in GHG emissions and removals

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

Greenhouse gases (CO_2, CH_4, N_2O, HFCs and SF_6) emission trends for 1990-2017, without consideration of the LULUCF sector, are provided in table below. In 1990, these emissions totaled 45,813 Gigagrams in CO_2 equivalent. Due to the collapse of the economic system of the Soviet period, emissions started to fall sharply. In 2017, GHG emissions amounted to 17,766 Gg. CO_2 equivalent[37].

Table 2-1 GHG Emission Trends in Georgia During 1990-2017 (Gg CO_2 eq.) excluding LULUCF

Gas/Year	CO_2	CH_4	N_2O	HFC-134a	HFC-125	HFC-143a	HFC-32	PFCs	SF_6	NF3	Total
1990	34,097.77	9,288.91	2,426.51	NA	NA	NA	NA	NA	NE	NA	**45,813**
1991	25,692.44	8,540.44	2,152.57	NA	NA	NA	NA	NA	NE	NA	**36,385**
1992	20,496.33	7,819.22	1,802.06	NA	NA	NA	NA	NA	NE	NA	**30,118**
1993	15,726.21	6,972.08	1,698.80	NA	NA	NA	NA	NA	NE	NA	**24,397**
1994	10,255.88	4,057.05	1,432.52	NA	NA	NA	NA	NA	NE	NA	**15,745**
1995	7,208.45	3,944.06	1,543.04	NA	NA	NA	NA	NA	NE	NA	**12,696**
1996	6,332.33	4,521.04	2,109.23	NA	NA	NA	NA	NA	C	NA	**12,963**
1997	5,385.22	4,373.06	2,234.49	NA	NA	NA	NA	NA	C	NA	**11,993**
1998	4,776.89	4,405.12	1,836.76	NA	NA	NA	NA	NA	C	NA	**11,019**
1999	4,371.96	3,830.09	2,153.86	NA	NA	NA	NA	NA	C	NA	**10,356**
2000	4,874.75	4,204.08	1,844.25	NA	NA	NA	NA	NA	C	NA	**10,923**

[35] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf (pg. 6.16)

[36] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf (pg. 6.26)

[37] The discrepancies may appear in total values due to rounding effect.

Gas/Year	CO_2	CH_4	N_2O	HFC-134a	HFC-125	HFC-143a	HFC-32	PFCs	SF_6	NF3	Total
2001	3,741.50	3,953.12	1,896.87	0.11	0.05	0.06	0.00[38]	NE	C	NA	**9,592**
2002	3,278.30	5,326.10	2,149.07	0.46	0.19	0.20	0.01	NE	C	NA	**10,754**
2003	3,458.88	5,924.18	2,230.22	1.46	0.64	0.47	0.07	NE	C	NA	**11,616**
2004	3,870.84	5,914.30	1,917.07	2.43	1.42	0.99	0.17	NE	C	NA	**11,707**
2005	4,759.76	4,459.33	1,940.05	4.59	2.33	1.73	0.27	NE	C	NA	**11,168**
2006	5,441.69	5,638.35	2,010.66	4.69	2.22	1.53	0.27	NE	C	NA	**13,099**
2007	6,499.91	5,340.34	1,774.80	5.31	2.14	1.45	0.26	NE	C	NA	**13,624**
2008	5,837.42	4,511.38	1,840.29	7.81	3.09	2.71	0.30	NE	C	NA	**12,203**
2009	6,192.01	4,133.36	1,856.39	12.84	4.07	3.61	0.39	NE	C	NA	**12,203**
2010	7,004.96	4,798.58	1,830.52	26.41	12.86	13.91	0.89	NE	C	NA	**13,688**
2011	8,898.12	5,276.69	1,787.43	30.54	17.31	14.54	1.82	NE	C	NA	**16,027**
2012	9,320.10	5,587.74	1,926.17	56.77	19.06	15.01	2.14	NE	C	NA	**16,927**
2013	8,711.96	4,957.75	2,190.26	65.07	21.33	15.24	2.62	NE	C	NA	**15,964**
2014	9,582.52	5,034.74	2,122.72	68.38	30.71	16.94	4.52	NE	C	NA	**16,861**
2015	10,250.94	5,645.66	2,177.69	77.83	37.61	17.98	5.97	NE	C	NA	**18,214**
2016	10,507.79	5,739.05	2,151.97	73.16	40.16	14.61	7.13	NE	C	NA	**18,534**
2017	10,688.51	4,941.06	1,980.96	81.69	48.85	15.92	8.87	NE	C	NA	**17,766**

2.2. Description and Interpretation of Emission and Removal Trends by Categories

Emission trends by sectors over 1990-2017 years period are provided in the Table 1.5. As it is clear from the table, energy is the dominant sector, and it accounts for more than half of the total emissions over the entire period, excluding LULUCF. Following the disintegration of the Soviet Union, the contribution of the agricultural sector in the total emissions grows gradually, and it ranks second over the period of 1990-2017. IPPU and Waste sectors are on the third and fourth places in ranking, excluding LULUCF.

In Georgia, LULUCF sector had a net sink of greenhouse gases during 1990-2017 years period. The sink capacity of the LULUCF sector fluctuates between (-4,145) Gg CO_2 eq and (-6,625) Gg CO_2 eq. In 2017 greenhouse gas emissions in Georgia totaled 17,766 Gg in CO_2 equivalent without consideration of the LULUCF sector, and 12,842 Gg CO_2 eq when taking this sector into account.

Table 2-2 GHGs Emission Trends by Sectors in 1990-2015 (Gg CO_2 eq.)

Sector	Energy	IPPU	Agriculture	Waste	LULUCF (Net removals)	Total (excluding LULUCF)	Total (including LULUCF)
1990	36,698	3,879	4,102	1,135	(6,353)	**45,813**	**39,460**
1991	28,529	3,038	3,713	1,106	(6,416)	**36,385**	**29,970**
1992	24,224	1,705	3,079	1,110	(6,312)	**30,118**	**23,805**
1993	19,678	776	2,831	1,112	(6,548)	**24,397**	**17,849**
1994	11,558	414	2,683	1,091	(6,625)	**15,745**	**9,120**
1995	8,319	447	2,805	1,125	(6,273)	**12,696**	**6,423**
1996	7,931	535	3,344	1,153	(6,022)	**12,963**	**6,941**
1997	6,783	504	3,526	1,180	(5,965)	**11,993**	**6,028**
1998	6,125	502	3,184	1,208	(5,521)	**11,019**	**5,498**
1999	4,849	710	3,560	1,237	(5,324)	**10,356**	**5,032**
2000	5,612	725	3,317	1,269	(5,031)	**10,923**	**5,892**
2001	4,391	439	3,474	1,288	(4,889)	**9,592**	**4,703**
2002	5,139	591	3,719	1,305	(4,778)	**10,754**	**5,976**
2003	5,763	699	3,833	1,321	(4,407)	**11,616**	**7,209**
2004	6,086	846	3,436	1,339	(4,145)	**11,707**	**7,562**

[38] 0.00345

Sector	Energy	IPPU	Agriculture	Waste	LULUCF (Net removals)	Total (excluding LULUCF)	Total (including LULUCF)
2005	5,396	957	3,461	1,354	(4,163)	**11,168**	**7,006**
2006	7,258	1,136	3,329	1,376	(4,257)	**13,099**	**8,843**
2007	7,888	1,314	3,022	1,400	(4,362)	**13,624**	**9,263**
2008	6,267	1,383	3,132	1,421	(4,357)	**12,203**	**7,846**
2009	6,580	1,106	3,061	1,456	(4,727)	**12,203**	**7,476**
2010	7,707	1,443	3,055	1,483	(4,537)	**13,688**	**9,151**
2011	9,743	1,794	2,981	1,509	(4,864)	**16,027**	**11,163**
2012	10,294	1,872	3,223	1,538	(4,750)	**16,927**	**12,178**
2013	8,949	1,892	3,582	1,542	(4,834)	**15,964**	**11,130**
2014	9,642	2,035	3,633	1,551	(4,609)	**16,861**	**12,252**
2015	10,849	2,058	3,745	1,562	(4,617)	**18,214**	**13,597**
2016	11,355	1,822	3,798	1,559	(4,797)	**18,534**	**13,738**
2017	10,726	1,990	3,488	1,562	(4,924)	**17,766**	**12,842**

In the table below GHG emissions and removals from LULUCF sector are provided in Gg CO_2 equivalent.

Table 2-3 GHG Emissions and Removals from LULUCF sector (Gg CO2 eq.)

Source	Emission (GG CO_2 eq.)	Removal (GG CO_2)	Net removals
1990	3,394	9,747	**-6,353**
1991	3,432	9,848	**-6,416**
1992	3,519	9,831	**-6,312**
1993	3,398	9,946	**-6,548**
1994	3,435	10,061	**-6,625**
1995	3,546	9,819	**-6,273**
1996	3,579	9,601	**-6,022**
1997	3,532	9,498	**-5,965**
1998	3,750	9,270	**-5,521**
1999	3,702	9,025	**-5,324**
2000	3,747	8,779	**-5,031**
2001	3,726	8,615	**-4,889**
2002	3,673	8,451	**-4,778**
2003	3,881	8,288	**-4,407**
2004	3,977	8,122	**-4,145**
2005	4,050	8,213	**-4,163**
2006	4,083	8,340	**-4,257**
2007	4,090	8,452	**-4,362**
2008	4,160	8,517	**-4,357**
2009	3,879	8,606	**-4,727**
2010	4,016	8,554	**-4,537**
2011	3,825	8,689	**-4,864**
2012	3,754	8,503	**-4,750**
2013	3,835	8,669	**-4,834**
2014	3,866	8,475	**-4,609**
2015	3,905	8,522	**-4,617**
2016	3,772	8,569	**-4,797**
2017	3,813	8,737	**-4,924**

2.3. Description and Interpretation of Emission Trends for Precursors

Tables below show direct GHG emissions and precursors by sectors and sub-sectors for 1990 and 2017.

Table 2-4 Direct GHG Emissions and Precursors by Sectors and Sub-Sectors in 1990 (Gg)

Greenhouse Gas Source and Sink Categories	CO_2 Emissions (Gg)	CO_2 Removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NOx (Gg)	CO (Gg)	NMVOCs (Gg)	SOx (Gg)
Total National Emissions and Removals for 1990	**37,492**	**9,747**	**1,438**	**63**	**115**	**386**	**72**	**106**
1. Energy	**30,368.23**	**NO**	**294.84**	**0.46**	**103.81**	**354.44**	**59.86**	**105.23**
A. Fuel Combustion (sectoral approach)	30,294		8.56	0.46	103.81	354.44	59.86	105.23
1. Energy Industries	13,731.86		0.41	0.09	36.46	3.43	0.99	51.95
2. Manufacturing Industries and Construction	7,534.96		0.45	0.07	20.65	6.37	0.98	27.11
3. Transport	3,744.54		0.99	0.19	35.06	237.63	44.84	11.84
4. Other Sectors	5,282.99		5.58	0.09	11.64	107.01	13.05	14.33
5. Non-Specified	0		1.13	0.02	0	0	0	0
B. Fugitive Emissions from Fuels	73.88		286.28		NE	NE	NE	NE
1. Solid Fuels	62.20		32.21		NE	NE	NE	NE
2. Oil and Natural Gas	11.68		254.07		NE	NE	NE	NE
C. CO2 transport and storage	NO	NO						
2. Industrial Processes	**C**	**NA**	**0.04**	**C**	**NO**	**1.58**	**11.92**	**0.39**
A. Mineral Products	571.93				NA	NA	NA	0.39
B. Chemical Industry	C		NA	C	NA	1.58	0.94	0.01
C. Metal Production	2,633.05		0.04	NA	NA	NA	NA	NA
D. Non-Energy Products from Fuel and Solvent Use	0		NA	NA	NA	NA	NA	NA
E. Electronic Industry	NO		NO	NO	NO	NO	NO	NO
F. Product Uses as Substitutes for ODS								
G. Other Product Manufacture and Use	C		NA	C	NA	NA	NA	NA
H. Other (please specify)	NA		NA	NA	NA	NA	10.98	NA
3. Agriculture	**NA**	**NA**	**95.98**	**6.72**	**10.70**	**0.50**	**NE**	**NE**
A. Enteric Fermentation			89.67					
B. Manure Management			5.80	1.17			NE	
C. Rice Cultivation			NO				NO	
D. Agricultural Soils			NE	5.54			NE	
E. Prescribed Burning of Savannahs			NO	NO	NO	NO	NO	
F. Field Burning of Agricultural Residues			0.51	0.01	10.70	0.50	NE	
G. Other			NO	NO	NO	NO	NO	
4. Land-use Change and Forestry	**3,393.66**	**9,746.73**	**2.01**	**0.02**	**0.16**	**29.07**	**NA**	**NA**
A. Changes in Forest and Other Woody Biomass Stocks	492.67	6,716.84						
B. Forest and Grassland conversion	NE	NE	NE	NE	NE	NE		

Greenhouse Gas Source and Sink Categories	CO_2 Emissions (Gg)	CO_2 Removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NOx (Gg)	CO (Gg)	NMVOCs (Gg)	SOx (Gg)
C. Abandonment of Managed Lands		NE						
D. CO2 Emissions and Removals from Soil	2,900.99	3,029.89						
E. Other	NE	NE	2.01	0.02	0.16	29.07		
5. Waste	**NA**	**NA**	**1,045.00**	**55.00**	**NE**	**NE**	**NE**	**NO**
A. Solid Waste Disposal on Land			619.00		NE		NE	
B. Waste-water Handling			426.00	55.00	NE	NE	NE	
C. Waste Incineration					NO	NO	NO	NO
D. Other			NO	NO	NO	NO	NO	NO
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items								
International Bunkers	**608.63**		**0.00**	**0.02**	**NE**	**NE**	**NE**	**NE**
Aviation	608.63		0.004	0.017	NE	NE	NE	NE
Marine	NE		NE	NE	NE	NE	NE	NE
CO2 Emissions from Biomass	**2,149**							

Table 2-5 Anthropogenic Emissions of HFCs, PFCs and SF6 in 1990 (Gg)

Greenhouse Gas Source and Sink Categories	HFCs (Gg)				PFCs (Gg)			SF_6 (Gg)
	HFC-23	HFC-134	HFC-125	HFC-143a	CF4	C2F6	Other	
Total National Emissions and Removals 1990	**NE**	**NE**	**NE**	**NO**	**NE**	**NE**	**NE**	**NE**
1. Energy								
A. Fuel Combustion (sectoral approach)								
1. Energy Industries								
2. Manufacturing Industries and Construction								
3. Transport								
4. Other Sectors								
5. Other								
B. Fugitive Emissions from Fuels								
1. Solid Fuels								
2. Oil and Natural Gas								
C. CO2 transport and storage								

Greenhouse Gas Source and Sink Categories			HFCs (Gg)				PFCs (Gg)			SF$_6$ (Gg)
			HFC-23	HFC-134	HFC-125	HFC-143a	CF4	C2F6	Other	
2. Industrial Processes			NO, NA, NE	NO, NA, NE	NO, NA, NE	NO, NA	NO, NE	NO, NE	NO, NE	NO, NE
	A. Mineral Products									
	B. Chemical Industry									
	C. Metal Production		NO	NO	NO	NO	NO	NO	NO	NO
	D. Non-Energy Products from Fuel and Solvent Use									
	E. Electronic Industry		NO	NO	NO	NO	NO	NO	NO	NO
	F. Product Uses as Substitutes for ODS		NA	NA	NA	NA	NE	NE	NE	NE
	G. Other Product Manufacture and Use		NE	NE	NE		NE	NE		NE
	H. Other (please specify)									
3. Agriculture										
	A. Enteric Fermentation									
	B. Manure Management									
	C. Rice Cultivation									
	D. Agricultural Soils									
	E. Prescribed Burning of Savannahs									
	F. Field Burning of Agricultural Residues									
	G. Other									
4. Land-use Change and Forestry										
	A. Changes in Forest and Other Woody Biomass Stocks									
	B. Forest and Grassland Conversion									
	C. Abandonment of Managed Lands									
	D. CO2 Emissions and Removals from Soil									
	E. Other									
5. Waste										
	A. Solid Waste Disposal on Land									
	B. Waste-water Handling									
	C. Waste Incineration									
	D. Other									
6. Other (please specify)			NO	NO	NO	NO	NO	NO	NO	NO
Memo Items										
	International Bunkers									
		Aviation								
		Marine								

Greenhouse Gas Source and Sink Categories	HFCs (Gg)				PFCs (Gg)			SF_6 (Gg)
	HFC-23	HFC-134	HFC-125	HFC-143a	CF4	C2F6	Other	
CO2 Emissions from Biomass								

Table 2-6 Direct GHG Emissions and Precursors by Sectors and Sub-Sectors in 2017 (Gg)

Greenhouse Gas Sources and Sink Categories	CO_2 Emissions (Gg)	CO_2 Removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NOx (Gg)	CO (Gg)	NMVOCs (Gg)	SOx (Gg)
Total National Emissions and Removals for 2017	**14,501**	**8,737**	**1,702**	**66**	**61**	**1,439**	**54**	**19**
1. Energy	**9,083**	**NO**	**74**	**0.2920**	**50**	**296**	**50**	**18**
A. Fuel Combustion (sectoral approach)	9,070.91		6.58	0.29	49.96	296.42	49.88	18.00
1. Energy Industries	1,529.88		0.02	0.01	2.93	0.38	0.09	0.30
2. Manufacturing Industries and Construction	1,009.68		0.08	0.01	4.22	1.97	0.26	5.37
3. Transport	4,044.00		1.69	0.21	38.58	215.60	40.11	11.58
4. Other Sectors	2,487.35		4.78	0.07	4.23	78.47	9.42	0.75
5. Non-Specified	NO		NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	12.15		67.37		NE	NE	NE	NE
1. Solid Fuels	10.06		0		NE	NE	NE	NE
2. Oil and Natural Gas	2.09		67.37		NE	NE	NE	NE
C. CO2 transport and storage	NO	NO						
2. Industrial Processes	**C**	**NA**	**NA**	**C, NA, NO**	**NA, NO**	**1.67**	**4.10**	**0.60**
A. Mineral Products	727.25				NA	NA	0.36	0.59
B. Chemical Industry	C		NA	C	NA	1.66	0.99	0.01
C. Metal Production	463.69		0.003	NA	NA	NA	NA	NA
D. Non-Energy Products from Fuel and Solvent Use	10.25		NA	NA	NA	0.01	0.04	NA
E. Electronic Industry	NO		NO	NO	NO	NO	NO	NO
F. Product Uses as Substitutes for ODS								
G. Other Product Manufacture and Use	C		NA	C	NA	NA	NA	NA
H. Other (please specify)	NA		NA	NA	NA	NA	2.71	NA
3. Agriculture	**NA**	**NA**	**89.78**	**5.17**	**4.80**	**0.20**	**NE**	**NA**
A. Enteric Fermentation			87.12					
B. Manure Management			2.43	1.09			NE	
C. Rice Cultivation			NO				NO	

Greenhouse Gas Sources and Sink Categories	CO_2 Emissions (Gg)	CO_2 Removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NOx (Gg)	CO (Gg)	NMVOCs (Gg)	SOx (Gg)
D. Agricultural Soils			NE	4.07			NE	
E. Prescribed Burning of Savannahs			NO	NO	NO	NO	NO	
F. Field Burning of Agricultural Residues			0.23	0.01	4.80	0.20	NE	
G. Other			NO	NO	NO	NO	NO	
4. Land-use Change and Forestry	**3,812.72**	**8,736.57**	**78.97**	**0.97**	**6.14**	**1,140.66**	**NA**	**NA**
A. Changes in Forest and Other Woody Biomass Stocks	900.62	6,478.75						
B. Forest and Grassland conversion	NE	NE	NE	NE	NE	NE		
C. Abandonment of Managed Lands		NE						
D. CO2 Emissions and Removals from Soil	2,912.10	2,257.82						
E. Other	NE	NE	78.97	0.97	6.14	1,140.66		
5. Waste	**NA**	**NA**	**1,459.00**	**59.00**	**NE**	**NE**	**NE**	**NO**
A. Solid Waste Disposal on Land			1,073.00		NE		NE	
B. Waste-water Handling			386.00	59.00	NE	NE	NE	
C. Waste Incineration					NO	NO	NO	NO
D. Other			NO	NO	NO	NO	NO	NO
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items								
International Bunkers	**296.92**		**0.002**	**0.008**	**NE**	**NE**	**NE**	**NE**
Aviation	292.23		0.0020	0.0082	NE	NE	NE	NE
Marine	4.69		0.0004	0.0001	NE	NE	NE	NE
CO2 Emissions from Biomass	**1,702**							

Table 2-7 Anthropogenic Emissions of HFCs, PFCs and SF6 in 2017 (Gg)

Greenhouse Gas Source and Sink Categories	HFCs (Gg)				PFCs (Gg)			SF_6 (Gg)
	HFC-23	HFC-134	HFC-125	HFC-143a	CF4	C2F6	Other	
Total National Emissions and Removals 2017	**0.063**	**0.017**	**0.004**	**0.014**	**NE**	**NE**	**NE**	**C**
1. Energy								
A. Fuel Combustion (sectoral approach)								
1. Energy Industries								
2. Manufacturing Industries and Construction								

Greenhouse Gas Source and Sink Categories	HFCs (Gg)				PFCs (Gg)			SF_6 (Gg)
	HFC-23	HFC-134	HFC-125	HFC-143a	CF4	C2F6	Other	
3. Transport								
4. Other Sectors								
5. Other								
B. Fugitive Emissions from Fuels								
1. Solid Fuels								
2. Oil and Natural Gas								
C. CO2 transport and storage								
2. Industrial Processes	**0.06**	**0.02**	**0.004**	**0.01**	**NO, NE**	**NO, NE**	**NO, NE**	**NO, NE, C**
A. Mineral Products								
B. Chemical Industry								
C. Metal Production	NO	NO	NO	NO	NO	NO	NO	NO
D. Non-Energy Products from Fuel and Solvent Use								
E. Electronic Industry	NO	NO	NO	NO	NO	NO	NO	NO
F. Product Uses as Substitutes for ODS	0.06	0.02	0.004	0.01	NE	NE	NE	NE
G. Other Product Manufacture and Use	NE	NE	NE		NE	NE		C
H. Other (please specify)								
3. Agriculture								
A. Enteric Fermentation								
B. Manure Management								
C. Rice Cultivation								
D. Agricultural Soils								
E. Prescribed Burning of Savannahs								
F. Field Burning of Agricultural Residues								
G. Other								
4. Land-use Change and Forestry								
A. Changes in Forest and Other Woody Biomass Stocks								
B. Forest and Grassland Conversion								
C. Abandonment of Managed Lands								
D. CO2 Emissions and Removals from Soil								
E. Other								
5. Waste								

Greenhouse Gas Source and Sink Categories			HFCs (Gg)				PFCs (Gg)			SF_6 (Gg)
			HFC-23	HFC-134	HFC-125	HFC-143a	CF4	C2F6	Other	
	A. Solid Waste Disposal on Land									
	B. Waste-water Handling									
	C. Waste Incineration									
	D. Other									
6. Other (please specify)			**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo Items										
	International Bunkers									
		Aviation								
		Marine								
	CO2 Emissions from Biomass									

Chapter 3. Energy (CRF Sector 1)

3.1. Overview of the Sector

Emissions from the energy sector consist of two main categories: fuel combustion and fugitive emissions from fuels. Fuel combustion includes emissions released into the atmosphere when fossil fuels (e.g., coal, oil products and natural gas) are combusted. Fugitive emissions are intentional or unintentional releases of gases from fossil fuels by anthropogenic activities.

In Georgia, fossil fuels are used to produce energy for a wide variety of purposes (e.g., production, transportation, and consumption of energy products) and as a result CO_2 (Carbon Dioxide), CH_4 (Methane), N_2O (Nitrous Oxide), NO_X (Nitrogen Oxide), CO (Carbon Monoxide), and NMVOC (Non-Methane Volatile Organic Compounds) are emitted in the process.

The methodologies are shown in the *Table 3-1* below.

Table 3-1 Methodologies used in the energy sector

Categories	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1.A - Fuel Combustion	T1	D	T1	D	T1	D
1.A.1 - Energy Industries	T1	D	T1	D	T1	D
1.A.2 - Manufacturing Industries and Construction	T1	D	T1	D	T1	D
1.A.3 – Transport	T1	D	T1	D	T1	D
1.A.4 - Other Sectors	T1	D	T1	D	T1	D
1.A.4.a - Commercial/Institutional	T1	D	T1	D	T1	D
1.A.4.b – Residential	T1	D	T1	D	T1	D
1.A.4.c - Agriculture/Forestry/ Fishing/Fish Farms	T1	D	T1	D	T1	D
1.A.5 Non-Specified	T1	D	T1	D	T1	D
1.B - Fugitive Emissions from Fuels	T1	D	T1, T2	D, CS	T1	D
1.B.1 - Solid Fuels	T1	D	T1	D	NA	NA
1.B.2 - Oil and Natural Gas	T1	D	T1, T2	D, CS	T1	D
1.B.2.a – Oil	T1	D	T1	D	T1	D
1.B.2.b - Natural Gas	T1	D	T2	CS	T1	D
1.C. CO2 transport and storage	NA	NA				

Note: D: IPCC default, T1: Tier1, T2: Tier2, T3: Tier3, CS: country specific method or EF

In 2017, GHG emissions (CO_2, CH_4, N_2O) from the energy sector amounted to 10,726 Gg CO_2 equivalent, which is about 60% of Georgia's total GHG emissions (excluding LULUCF). In 2017, the following source categories had the largest shares in the total GHG emissions from the Energy Sector: Transport – 39%, Other Sectors – 24%, Oil and Natural Gas – 13%, Energy Industries – 14%, Manufacturing Industries and Construction – 9%. Compared to 1990, the total GHG emissions from the energy sector had decreased by 71%.

Table 3-2 Energy Sectoral Table for 1990 and 2017

Categories	1990 Emissions (Gg)			2017 Emissions (Gg)		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1 – Energy	30,368.23	294.84	0.44	9,083.06	73.95	0.29
1.A - Fuel Combustion	30,294.35	8.55	0.44	9,070.91	6.58	0.29

Categories	1990 Emissions (Gg)			2017 Emissions (Gg)		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1.A.1 - Energy Industries	13,731.86	0.41	0.09	1,529.88	0.02	0.01
1.A.2 - Manufacturing Industries and Construction	7,534.96	0.45	0.07	1,009.68	0.08	0.01
1.A.3 – Transport	3,744.54	0.99	0.19	4,044.00	1.69	0.21
1.A.4 - Other Sectors	5,282.99	5.58	0.09	2,487.35	4.78	0.07
1.A.4.a - Commercial/Institutional	1,076.52	0.45	0.01	417.08	0.09	0.00
1.A.4.b – Residential	3,688.24	4.89	0.07	1,777.79	4.67	0.06
1.A.4.c - Agriculture/Forestry/ Fishing	518.23	0.24	0.00	292.47	0.03	0.00
1.A.5 Non-Specified	0.00	1.13	0.02	NO	NO	NO
1.B - Fugitive Emissions from Fuels	73.88	286.29	0.00	12.15	67.369	0.00
1.B.1 - Solid Fuels	62.20	32.21	0.00	10.06	0.00	0.00
1.B.2 - Oil and Natural Gas	11.68	254.07	0.00	2.09	67.369	0.00
1.B.3 - Other emissions from Energy Production	NO	NO	NO	NO	NO	NO
1.C - CO2 Transport and Storage	NO	NO	NO	NO	NO	NO

A significant fall in GHG emissions in the 1990s is due to the collapse of the Soviet Union and fundamental changes in the economy of the country. However, the national economy started to grow since 2000 and the average annual growth of real GDP amounted to 8.4% prior to 2008. During 2008-2009, economic growth of Georgia has slowed down due to the Russian-Georgian war. Starting in 2010, the real GDP of the country began to increase again by 4.7% on average until 2018[39].

In 2010, hydro generation reached its maximum capacity, while the generation from thermal power plants was the lowest in the past decade. Since 2011 emissions in the energy sector increased mainly due to the increased thermal power generation and improvement of the economic situation. Table below shows the CO_2 equivalent of the emissions in the energy sector. The Global Warming Potentials used to convert from GHG to CO_2 eq are reflected in the second assessment report.

Table 3-3 GHG Emissions from the Energy Sector (Gg, CO_2 eq.)

Year	1A - Fuel Combustion	1B - Fugitive Emissions from Fuels	1C - CO2 Transport and Storage	Total from Energy Sector
1990	30,612	6,086	NO	36,698
1991	23,030	5,499	NO	28,529
1992	19,191	5,033	NO	24,225
1993	15,454	4,224	NO	19,678
1994	10,032	1,527	NO	11,559
1995	7,063	1,256	NO	8,319
1996	6,255	1,676	NO	7,930
1997	5,254	1,529	NO	6,782
1998	4,598	1,528	NO	6,125
1999	4,030	820	NO	4,850
2000	4,508	1,104	NO	5,611
2001	3,580	810	NO	4,390

[39] GEOSTAT – Real Growth of GDP.

Year	1A - Fuel Combustion	1B - Fugitive Emissions from Fuels	1C - CO2 Transport and Storage	Total from Energy Sector
2002	3,027	2,112	NO	5,138
2003	3,110	2,653	NO	5,762
2004	3,390	2,697	NO	6,087
2005	4,123	1,274	NO	5,397
2006	4,659	2,600	NO	7,259
2007	5,558	2,331	NO	7,889
2008	4,822	1,446	NO	6,267
2009	5,470	1,111	NO	6,581
2010	6,014	1,693	NO	7,707
2011	7,565	2,180	NO	9,745
2012	7,932	2,363	NO	10,295
2013	7,394	1,554	NO	8,949
2014	8,154	1,489	NO	9,643
2015	8,818	2,032	NO	10,849
2016	9,252	2,103	NO	11,355
2017	9,300	1,427	NO	10,726

As can be seen from the Table, a large share of the emissions from the energy sector is due to fuel combustion (87% in 2017) and the remaining 13% is caused by fugitive emissions. Among emission source-categories, the highest growth relative to 2000 was noted in fugitive emissions from the transformation of solid fuel (5 Gg CO_2 eq. in 2000, 132 Gg CO_2 eq. in 2016), which took place as a result of the intensification of coal mining works in recent years. However, since 2017 coal mining has significantly decreased due to the technical inspection of safety norms of mines, following the deadly workplace accidents[40].

Emissions by greenhouse gases are shown in table below.

Table 3-4 GHG Emissions from the Energy Sector (Gg)

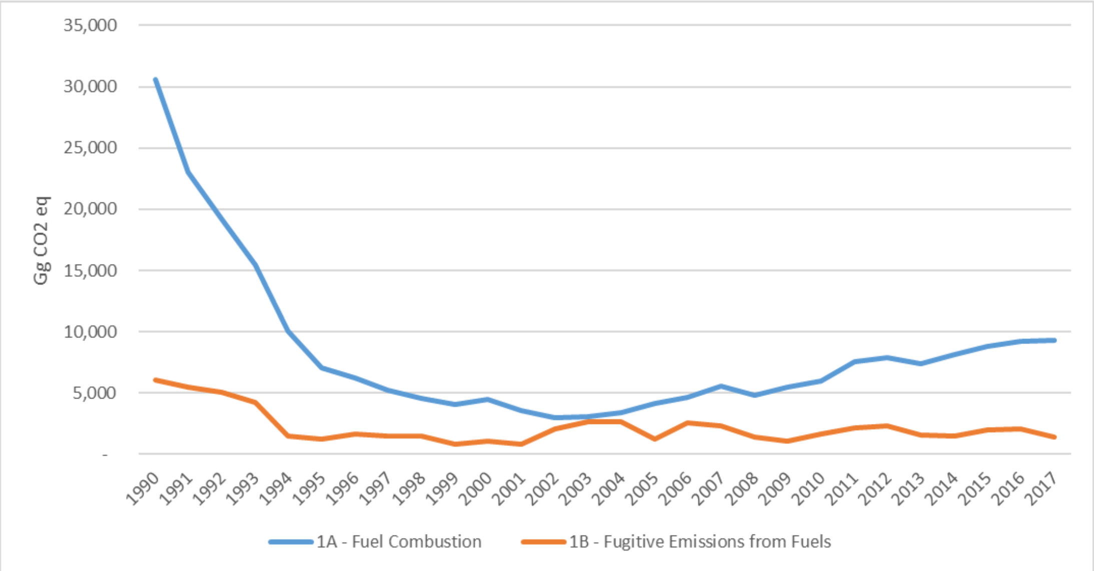
Gas	CO_2	CH_4	CH4 in CO_{2eq}	N_2O	N2O in CO_{2eq}	Total CO_2eq
1990	30,368	294.86	6,192	0.44	138	**36,698**
1991	22,803	267.85	5,625	0.33	101	**28,529**
1992	18,894	249.21	5,233	0.31	97	**24,224**
1993	15,053	215.25	4,520	0.34	105	**19,678**
1994	9,887	77.11	1,619	0.17	52	**11,559**
1995	6,820	68.57	1,440	0.19	59	**8,319**
1996	5,894	92.66	1,946	0.29	91	**7,931**
1997	4,968	82.94	1,742	0.24	73	**6,782**
1998	4,352	81.62	1,714	0.19	59	**6,125**
1999	3,796	47.54	998	0.18	55	**4,850**
2000	4,290	60.49	1,270	0.17	52	**5,612**
2001	3,359	46.62	979	0.17	53	**4,391**

[40] Miners' Deaths Spark Protests In Georgia

Gas	CO_2	CH_4	CH4 in CO_{2eq}	N_2O	N2O in CO_{2eq}	Total CO_2eq
2002	2,804	108.66	2,282	0.17	53	**5,138**
2003	2,891	134.22	2,819	0.17	53	**5,763**
2004	3,169	136.40	2,864	0.17	53	**6,087**
2005	3,977	65.52	1,376	0.14	43	**5,396**
2006	4,504	129.02	2,709	0.15	45	**7,259**
2007	5,384	116.73	2,451	0.17	53	**7,889**
2008	4,659	74.28	1,560	0.15	48	**6,267**
2009	5,300	58.33	1,225	0.18	55	**6,581**
2010	5,840	85.94	1,805	0.20	62	**7,707**
2011	7,412	108.16	2,271	0.20	60	**9,744**
2012	7,782	116.52	2,447	0.21	65	**10,295**
2013	7,169	80.91	1,699	0.26	80	**8,949**
2014	7,913	78.11	1,640	0.29	89	**9,643**
2015	8,591	103.25	2,168	0.29	90	**10,850**
2016	9,020	106.52	2,237	0.32	98	**11,355**
2017	9,083	73.95	1,553	0.29	90	**10,726**

During 2000-2017, GHGs emissions from the manufacturing industry and transport sectors increased about 1.5 and 4.4 times, respectively. In the transport sector, GHG emissions increased due to the growing auto-park and a majority share of second-hand cars in the park. In Georgia, the number of motor vehicles in 2002-2016 period increased from 319,600 to 1,126,470[41]. Since 2006, the development of energy transit pipelines (South Caucasus Gas Pipeline, Baku-Tbilisi-Erzurum oil Pipeline) through Georgia required additional gas and diesel for the pipeline operation. Figure 1 shows GHG emission trends in 1990-2017 years period in the energy sector.

Figure 3-1 Trend of GHG Emissions from The Energy Sector 1990-2017 (Gg CO_2 eq.)



Results of uncertainty analysis in energy sector is provided in sub-chapter 1.3

[41] Ministry of Internal Affairs, 2016

Non-CO_2 Emissions from Energy Sector

Non-CO_2 emissions, such as CO, NOx, NMVOC and SO_2, were calculated using the Tier 1 approach in fuel combustion. The Tier 1 methodology for non-CO_2 gases estimates emissions by applying Emission Factors to fuel statistics, which are organized by sector. Emissions of these gases depend on the fuel type used, combustion technology, operating conditions, control technology, and on maintenance and age of the equipment. However, since Georgia does not have such detailed data, the Tier 1 methodology was used, ignoring these refinements. Table below provides estimates of non-CO_2 emissions from fuel combustion for the period of 1990-2017.

Table 3-5 Precursor Gas Emissions in Energy Sector

Non-CO_2 From Fuel Combustion (Tier 1) Gg	CO	NOx	NMVOCs	SO2
1990	354	104	60	105
1991	310	71	52	42
1992	305	63	47	51
1993	358	53	52	40
1994	157	37	25	34
1995	201	30	28	27
1996	444	40	70	14
1997	354	32	55	13
1998	260	26	39	14
1999	244	22	36	11
2000	209	22	30	10
2001	245	19	37	5
2002	249	18	38	5
2003	251	18	38	4
2004	239	19	36	5
2005	200	23	33	7
2006	205	25	33	7
2007	242	28	40	9
2008	215	23	35	9
2009	225	28	36	12
2010	246	32	41	15
2011	227	37	38	16
2012	308	39	47	17
2013	257	40	41	16
2014	262	46	42	16
2015	266	50	44	18
2016	326	54	55	19
2017	296	50	50	18

In 2017, the transport and the residential sectors contributed about 73% and 26% respectively in CO emissions. While transport sector (77%) was a key contributor in NOx emissions. 80% and 18% respectively was the share of the transport and the residential sectors in NMVOC emissions in the same year. Manufacturing industry and the transport sectors had 30% and 64% shares respectively in SO_2 emission.

3.2. Fuel Combustion (1.A.)

a) Source-category description and calculated emissions

Emissions of greenhouse gases from the Fuel Combustion source-category totaled 9,300 Gg in CO_2eq in 2017. In that year, carbon dioxide, methane and nitrous oxide accounted for 85%, 14%, and 1% of emissions from fuel combustion source-category, respectively. The transport sector has the highest share of 39% in GHGs emissions from the source. The residential sector has the highest contribution in methane emissions, and transport sector - in nitrous oxide emissions.

b) Methodological issues

- ***Estimation Method***

Emissions in the source-category are calculated using the IPCC methodology Tier 1 – sectoral approach. The sectoral approach for assessing emissions from Fuel Combustion Stationary Source-categories is based on the data on actual consumption of fuel combusted in the source category provided in the country's energy balance and emission factor. Emission Factors are derived from the default values provided together with associated uncertainty range.

The following equation is used to calculate greenhouse gas emissions from stationary combustion according to the sectoral approach:

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

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 CO2, it includes the carbon oxidation factor, assumed to be 1.

Not all fuel supplied to an economy is combusted for heat energy. Certain volume is used as a feedstock for manufacturing of products, such as plastics or in a non-energy use (e.g. bitumen for road construction), without oxidation (emissions) of carbon. This is called stored carbon and is deducted from the carbon emissions calculation. The estimation of the stored carbon requires data for fuel consumption by activities using the fuel as raw material.

Recalculations in GHGs emission inventories for previous years were carried out are mainly due to shifting from IPCC 1996 to IPCC 2006 guidelines and availability of the new data sources.

- ***Emission Factors***

The emission factor is a coefficient that relates the Activity Data to the amount of the chemical compound, which is the source of later emissions. Emission Factors for CO_2 from fossil fuel combustion are expressed on a per unit energy basis, since the carbon content of fuels is generally less variable when expressed on a per unit energy basis, compared to per unit mass basis. Therefore, net calorific values (NCVs) are used to convert fuel consumption data on a per unit mass or volume basis, to data on a per unit energy basis. Country specific NCV-s of different fuels were obtained from the GEOSTAT energy balance (2013-2017).

Table 3-6 Conversion Factors and Carbon Emission Factors for Various Types of Fuel

Fuel type	Unit	Net Calorific Values (TJ/Unit)	Carbon content (kg C/GJ)
Crude Oil	1000 t	42.5	20.0
Motor Gasoline	1000 t	44.0	18.9
Jet Kerosene	1000 t	43.2	19.5
Other Kerosene	1000 t	43.2	19.6
Gas/Diesel Oil	1000 t	43.3	20.2
Residual Fuel Oil	1000 t	40.4	21.1
LPG	1000 t	45.0	17.2
Naphtha	1000 t	44.5	20.0
Bitumen	1000 t	38.0	22.0
Lubricants	1000 t	38.0	20.0
Fuel Oil	1000 t	41.9	20.0
Other Oil Products	1000 t	43.3	20.0
Anthracite	1000 t	29.3	26.8
Lignite	1000 t	17.0	27.6
Sub-Bituminous Coal	1000 t	18.9	26.2
Other-Bituminous Coal	1000 t	25.0	25.8
Coking Coal	1000 t	28.2	25.8
Coke Oven/Gas Coke	1000 t	29.3	29.2
Natural Gas (Ng)	1 000 000 m^3	35.0	15.3
Fuel Wood	1000 m^3	7.8	30.5
Petroleum Coke	1000 t	32.5	26.6
Charcoal	1000 t	30.8	26.6
Patent Fuel	1000 t	29.0	26.6
Other Primary Solid Biomass	1000 t	18.0	27.3

Emission Factors for CO_2 are in units of kg CO_2/GJ on a net calorific value basis and reflect the carbon content of the fuel. CO_2 Emission Factors for all Tiers reflect the full carbon content of the fuel less any non-oxidized fraction of carbon retained in the ash, particulates, or soot. Since this fraction is generally small, the Tier 1 default Emission Factors neglect this effect by assuming a complete oxidation of the carbon contained in the fuel (carbon oxidation factor equal to 1). Emission Factors for CH_4 and N_2O for different source categories differ due to the differences in combustion technologies applied in the various source categories. The default factors presented for Tier 1 apply to technologies without emission controls[42].

- ***Activity Data***

Generally, in the energy sector the national energy balance is the basis for the assessment of greenhouse gas emissions during fuel combustion. In production of fuel, its import, export, changes in stocks and consumption, energy balance is provided in physical units (tons or m^3) or in energy units (terajoules or kilo tons of oil equivalent). For comparison of data in the energy balance, physical units are converted into energy units using fuel specific net calorific values (NCV).

In 2014, the National Statistics Office of Georgia (GEOSTAT) published its first energy balance for 2013. Quality of the data is improving year after year. Activity Data have been obtained from various sources.

The following data were provided from different sources:

  - Energy balances for 2013-2017 were provided by the National Statistics Office of Georgia (GEOSTAT)[43];
  - Energy balances for 1990-2012 were provided by the International Energy Agency (IEA);

[42] The Emission Factor Database (EFDB)
[43] GEOSTAT - Energy Statistics

- Natural gas balances for 2010-2012, jet kerosene and firewood supply, and consumption data were obtained from the Ministry of Energy of Georgia;
- Information on the natural gas and crude oil transit were provided by the Georgian Oil and Gas Corporation (GOGC)[44];
- Electricity balances for 2007-2017 years were obtained from the Electricity Market Operator (ESCO)[45];
- Natural gas transmission and distribution losses were provided by the Georgian National Energy and Water Supply Regulatory Commission (GNERC)[46];
- Data for natural gas and diesel consumption in operations of energy transit pipelines for 2010-2017 years period were provided by the British Petroleum Georgia[47].

Based on the data provided, aggregated energy balances were developed for the period of 1990-2012 years.

3.2.1. The Sectoral Approach vs the Reference Approach

This chapter explains a comparison between the reference approach and the sectoral approach in accordance with the UNFCCC Inventory Reporting Guidelines (Decision 24/CP.19 Annex I, paragraph 40). The Reference Approach is a top-down approach, using a country's energy supply data to calculate the emissions of CO_2 from combustion of mainly fossil fuels. The Reference Approach is a straightforward method that can be applied on the basis of relatively easily available energy supply statistics. Improved comparability between the sectoral and the reference approaches continues to allow a country to produce a second independent estimate of CO_2 emissions from fuel combustion with limited additional effort and data requirements. The Reference Approach provides an upper bound to CO_2 emissions inferred from the country's supply of fossil fuels by identifying the carbon content, subtracting from it the excluded carbon - carbon stored in non-energy products and products made from fuels used as raw material, adjusting for carbon, which remains unburnt, and multiplying by 44/12. Under the Reference Approach, carbon dioxide emissions are calculated using the following formula:

$$Carbon\ dioxide\ emission\ (Gg\ CO_2) = \sum_i \left\{ \left[\begin{array}{c} Apparent\ Consuption\ of\ fuel\ (Units) \\ \times\ Calorific\ value\ of\ fuel\ \left(\frac{TJ}{Unit}\right) \\ \times\ Carbon\ emission\ factor\ \frac{\left(\frac{tC}{TJ}\right)}{1000} - Excluded\ carbon \end{array} \right] \times Fraction\ of\ carbon\ oxidized \right\} \times \frac{44}{12}$$

Where the lower index *i* refers to the type of fuel, and apparent consumption for each primary fuel is calculated as:

$$Apparent\ Consumption\ = Production\ + Imports\ - Exports\ - International\ Bunkers\ - Stock\ Change$$

While for secondary fuels, apparent consumption is calculated as:

$$Apparent\ Consumption\ = Imports\ - Exports\ - International\ Bunkers\ - Stock\ Change$$

Usually the value of fraction of carbon oxidized is 1, reflecting complete oxidation.

---

[44] www.gogc.ge
[45] www.esco.ge
[46] www.gnerc.org
[47] www.bpgeorgia.ge

Excluded carbon is calculated using the formula:

$$Excluded\ Carbon\ (Gg\ C) = Non - energy\ use\ (10^3 t) \times\ Calorific\ value\ of\ fuel\left(\frac{TJ}{10^3 t}\right) \times Carbon\ emission\ factor\left(t\frac{C}{TJ}\right) \times Fraction\ of\ excluded\ carbon \times 10^3$$

The Reference approach is an upper bound, as some of the carbon will be emitted in forms other than CO_2, in part because complete combustion of the fuel is not always the case, and in addition, fuels may leak or evaporate. Consequently, the CO_2 emissions figure obtained from the Reference Approach will include carbon emitted as CH_4, CO, N_2O or NMVOC.

The Reference Approach uses a simple assumption: once carbon is brought into the national economy in fuel, it is either saved in some way or it must be released to the atmosphere. To calculate the carbon released, it is not necessary to know exactly how the fuel was used or what intermediate transformations it underwent. In this respect, the methodology may be termed a "top-down" approach compared with the "bottom-up" methods used for other gases. The "bottom-up" methods are a higher-level approach when the information about fuel consumption and Emission Factors is collected at the level of specific enterprises. The sectoral approach is an intermediate approach between these two approaches since it uses information about fuel consumption at the level of economic sectors. The difference between carbon dioxide emissions calculated using the Reference approach and sectoral approach, should not exceed 2%, otherwise the explanation for the difference should be provided.

Table below shows carbon dioxide emissions in 2016-2017, calculated using these two approaches for different types of fuel, followed by the explanation of differences.

Table 3-7 Comparison of CO_2 Emissions Calculated Using the Reference and the Sectoral Approaches

Fuel type	Year	2016	2017
Liquid Fuel	Reference approach, Gg	3,935	3,479
	Sectoral approach, Gg	3,967	3,489
	Difference, %	-0.82%	-0.28%
Solid Fuel	Reference approach, Gg	1,113	1,237
	Sectoral approach, Gg	1,114	1,235
	Difference, %	-0.09%	0.15%
Gas Fuel	Reference approach, Gg	4,192	4,310
	Sectoral approach, Gg	3,925	4,347
	Difference, %	6.81%	-0.85%
Other Fossil Fuels	Reference approach, Gg	0	0
	Sectoral approach, Gg	0	0
	Difference, %	0.00%	0.00%
Peat	Reference approach, Gg	0	0
	Sectoral approach, Gg	0	0
	Difference, %	0.00%	0.00%
Total	Reference approach, Gg	9,240	9,026
	Sectoral approach, Gg	9,007	9,071
	Difference, %	2.60%	-0.49%

6.81% difference in gas fuel in 2016 is due to the natural gas losses at the time of transportation and distribution, which is treated as methane emission, while under the reference approach it is treated as combusted and transformed into carbon dioxide.

3.2.2. International Bunker Fuels

All emissions from fuels used for international aviation and water-borne navigation (bunkers) are to be excluded from national totals and reported separately as memo items. Emissions from international aviation are defined as emissions from flights that depart in one country and arrive in a different country, including take-offs and landings for these flight stages.

Emissions from international water-borne navigation are sourced from fuels used by vessels of all flags that are engaged in international water-borne navigation. The international navigation may take place at sea, on inland lakes and waterways and in coastal waters. It includes emissions from journeys that depart in one country and arrive in a different country.

Table below provides emissions from the International Aviation and Marine Bunkers.

Table 3-8 GHG emissions from international bunkers

Year	International Aviation Bunkers					International Marine Bunkers				
	Jet Kerosene, TJ	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	Total in Gg CO2 eq	Diesel, Fuel Oil, TJ	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	Total in Gg CO_2 eq
1990	8,512	609	0.004	0.017	**614**	NE	NE	NE	NE	NE
1991	8,256	590	0.004	0.017	**596**	5,102	392	0.04	0.01	**395**
1992	7,095	507	0.004	0.014	**512**	3,644	280	0.03	0.01	**282**
1993	5,418	387	0.003	0.011	**391**	2,466	189	0.02	0.01	**191**
1994	2,765	198	0.001	0.006	**200**	2,168	166	0.02	0.00	**168**
1995	172	12	0.00	0.000	**12**	2,061	158	0.01	0.00	**160**
1996	3,354	240	0.002	0.007	**242**	NE	NE	NE	NE	NE
1997	2,967	212	0.001	0.006	**214**	NE	NE	NE	NE	NE
1998	4,128	295	0.002	0.008	**298**	NE	NE	NE	NE	NE
1999	3,483	249	0.002	0.007	**251**	NE	NE	NE	NE	NE
2000	648	46	0.000	0.001	**46**	NE	NE	NE	NE	NE
2001	559	40	0.000	0.001	**40**	NE	NE	NE	NE	NE
2002	989	71	0.000	0.002	**71**	809	60	0.01	0.00	**61**
2003	1,118	80	0.001	0.002	**81**	NE	NE	NE	NE	NE
2004	1,591	114	0.001	0.003	**115**	NE	NE	NE	NE	NE
2005	1,599	114	0.001	0.003	**115**	NE	NE	NE	NE	NE
2006	1,591	114	0.001	0.003	**115**	NE	NE	NE	NE	NE
2007	2,021	145	0.001	0.004	**146**	NE	NE	NE	NE	NE
2008	1,720	123	0.001	0.003	**124**	NE	NE	NE	NE	NE
2009	1,720	123	0.001	0.003	**124**	NE	NE	NE	NE	NE
2010	1,673	120	0.001	0.003	**121**	NE	NE	NE	NE	NE
2011	1,512	108	0.001	0.003	**109**	NE	NE	NE	NE	NE
2012	2,949	211	0.001	0.006	**213**	NE	NE	NE	NE	NE
2013	3,656	261	0.002	0.007	**263**	NE	NE	NE	NE	NE
2014	3,470	248	0.002	0.007	**250**	41	3	0.00	0.00	**3**
2015	3,002	215	0.002	0.006	**217**	61	5	0.00	0.00	**5**

Year	International Aviation Bunkers					International Marine Bunkers				
	Jet Kerosene, TJ	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	Total in Gg CO2 eq	Diesel, Fuel Oil, TJ	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	Total in Gg CO_2 eq
2016	3,048	218	0.002	0.006	**220**	24	2	0.00	0.00	**2**
2017	4,087	292	0.002	0.008	**295**	63	5	0.00	0.00	**5**

Due to the lack of data, information on GHG emissions from the consumption of fuel by international marine bunkers is only available for 1991-1995- and 2014-2017-years periods. Data for the 1991-1995 period were provided by IEA, while the data for the latest period were obtained from the Transport and Logistics Development Policy Department of the Ministry of Economy and Sustainable Development.

3.2.3. Feedstocks and Non-Energy Use of Fuels

Not all fuel supplied to an economy is burned for heat energy. Certain volume is used as a feedstock for manufacturing products such as plastics, or in a non-energy use (e.g. bitumen for road construction, natural gas for ammonia, naphtha, ethane, paraffin and candle production), without oxidation (emissions) of carbon. This is called excluded/stored carbon and is deducted from the carbon emissions calculation. The values of the consumption of fossil fuel products for non-energy purposes are provided in the table below.

Table 3-9 The Consumption of Fossil Fuel for Non-Energy Purposes (TJ)

Year	Lubricants (TJ)	Bitumen (TJ)	Natural gas (TJ)	Year	Lubricants (TJ)	Bitumen (TJ)	Natural gas (TJ)
1990	4,560	9,880	6,000	2004	462	1,443	3,815
1991	7,266	3,861	6,000	2005	380	2,584	7,385
1992	5,586	3,861	3,410	2006	630	2,613	7,273
1993	5,586	3,471	2,841	2007	714	3,900	2,902
1994	2,698	1,748	2,000	2008	714	3,783	3,052
1995	420	78	2,273	2009	0	312	3,070
1996	966	0	0	2010	386	3,542	4,078
1997	336	390	2,313	2011	520	2,273	4,422
1998	462	390	4,489	2012	644	3,878	4,646
1999	378	312	6,427	2013	571	3,005	8,798
2000	304	342	0	2014	638	3,105	9,058
2001	210	858	3,429	2015	755	3,378	9,539
2002	126	1,014	2,868	2016	796	3,980	7,784
2003	210	1,170	3,256	2017	699	3,990	8,593

Carbon emissions from the use of fuels listed above as feedstock are reported within the source categories of the Industrial Processes and Product Use (IPPU) chapter. Lubricating oil statistics usually cover use of lubricants in engines, as well as oils and greases for industrial purposes and heat transfer and cutting oils. Bitumen/asphalt is used for road paving and roof covering and the carbon it contains remains stored for long periods of time. Consequently, there are no fuel combustion emissions arising from the deliveries of bitumen within the year of the inventory. Natural gas is mainly used in production of fertilizers.

3.2.4. Energy Industries (1.A.1.)

a) Source-category description and calculated emissions

The energy industry source category comprises emissions from fuels combusted by the fuel extraction or energy-producing industries, including the following sub-categories:

- Main Activity Electricity and Heat Production includes emissions from main activity producers of electricity generation, combined heat and power generation, and heat plants. Main activity producers (formerly known as public utilities) are defined as undertakings which produce electricity and heat as their principal activity and supply it to the public. They may be in public or private ownership.
- Petroleum refining covers all combustion activities supporting the refining of petroleum products including on-site combustion for the generation of electricity and heat for own use.
- Manufacture of Solid Fuels and Other Energy Industries - combustion emissions from fuel use during manufacturing 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.
- Emissions from fuel combustion in coke ovens within the iron and steel industry should be reported under other energy industries (1A1c) rather than within manufacturing industry[48].

Currently, in Georgia, electric energy is produced mainly by hydropower plants (HPP) and gas thermal power plants (TPP). Georgia is a country rich with hydro resources and the largest share of power generation falls on hydropower plants. In 2017, the country has 76 HPPs (3,176 MW), 4 gas TPPs (911.2 MW), 1 coal TPP (13.2 MW) and 1 wind power plant (20.7 MW)[49].

The largest share of hydro power production – 93% in total power generation, can be noticed in 2010 due to the high level of precipitation. Starting from 2013 with increasing power consumption, thermal power generation increased. During 2010-2017, the average annual electricity consumption growth rate was 5%[50]. In 2013, four new hydro power plants with 46 MW installed capacity (250 GWh annual generation) were completed. In 2015 new Gardabani gas thermal power plant (230 MW installed capacity) was completed. Ten new HPPs were commissioned for 2015-2017 years period.

As for heat production, during the Soviet period, prior to 1991, centralized heating systems were operated in large cities of Georgia; these systems used natural gas and heavy fuel oil as fuel. Later, these systems gradually became fully useless; hence, greenhouse gas emissions from this subsector dropped to almost zero. Currently, most of the population uses firewood and natural gas for heating. Emissions from the consumption of these fuels are reflected in the residential sub-category.

Table 3-10 GHGs Emissions from the Energy Industry (Gg)

Gas/Sub-sectors	CO_2 in Gg	CH_4	CH4 in CO_{2eq}	N_2O	N2O in CO_{2eq}	Total in CO_{2eq}.	Electricity Generation (Gg in CO2eq.)	Heat Plants (Gg in CO2eq.)	Other Energy Industries (Gg in CO2eq.)
1990	13,732	0.41	8.61	0.087	26.97	**13,768**	6,217	7,551	0
1991	8,750	0.258	5.418	0.058	17.98	**8,773**	5,099	3,674	0
1992	8,035	0.221	4.641	0.046	14.26	**8,054**	3,779	4,275	0
1993	5,345	0.152	3.192	0.028	8.68	**5,357**	2,755	2,602	0
1994	4,078	0.128	2.688	0.023	7.13	**4,088**	2,737	1,351	0
1995	4,342	0.138	2.898	0.025	7.75	**4,352**	3,336	1,016	0
1996	1,199	0.031	0.651	0.005	1.55	**1,201**	1,201	0	0
1997	1,092	0.027	0.567	0.004	1.24	**1,093**	1,048	0	45.574
1998	1,284	0.03	0.63	0.004	1.24	**1,286**	1,252	0	33.743
1999	1,190	0.027	0.567	0.004	1.24	**1,192**	1,192	0	0

[48] IPCC 2006, Table 8.2
[49] GEOSTAT, Energy Balance 2017
[50] Electricity Market Operator (ESCO) – Electricity Balance

Gas/Sub-sectors	CO_2 in Gg	CH_4	CH4 in CO_{2eq}	N_2O	N2O in CO_{2eq}	Total in $CO_{2eq.}$	Electricity Generation (Gg in CO2eq.)	Heat Plants (Gg in CO2eq.)	Other Energy Industries (Gg in CO2eq.)
2000	1,445	0.03	0.63	0.004	1.24	**1,447**	1,447	0	0
2001	1,160	0.022	0.462	0.003	0.93	**1,162**	923	5	233.784
2002	782	0.016	0.336	0.003	0.93	**783**	377	205.522	200.777
2003	812	0.017	0.357	0.002	0.62	**813**	382	238	192.541
2004	1,018	0.021	0.441	0.003	0.93	**1,019**	541	255.416	223.466
2005	1,198	0.03	0.63	0.003	0.93	**1,200**	652	176	371
2006	1,521	0.029	0.609	0.003	0.93	**1,523**	1,042	96.197	384.662
2007	1,753	0.033	0.693	0.004	1.24	**1,755**	1283.564	148.784	322.787
2008	975	0.019	0.399	0.002	0.62	**976**	642	143.96	190.298
2009	1,352	0.029	0.609	0.004	1.24	**1,354**	824.849	349.21	179.807
2010	559	0.01	0.21	0.002	0.62	**560**	560	0	0
2011	1,273	0.02	0.42	0.003	0.93	**1,274**	1,274	0	0
2012	1,378	0.03	0.63	0.002	0.62	**1,379**	1,379	0	0
2013	999	0.02	0.42	0.002	0.62	**1,000**	953	0	47
2014	1,531	0.02	0.42	0.008	2.48	**1,534**	1,130	0	404
2015	1,619	0.03	0.63	0.007	2.17	**1,622**	1,275	0	347
2016	1,470	0.022	0.462	0.008	2.48	**1,473**	1,071	0	400.599
2017	1,530	0.023	0.483	0.009	2.79	**1,533**	1,088	0	444.794

b) Methodological issues

- ***Estimation Method***

Emissions have been calculated using the IPCC Tier 1 Sectoral Approach explained in the Paragraph above.

- ***Emission Factor***

Country specific net calorific values were used to convert the amount of consumed fuel from physical units into energy units (*Table 3-6*). The following default Emission Factors are provided in the table below[51].

Table 3-11 Default Emission Factors for Stationary Combustion in The Energy Industries (kg GHG/TJ on a Net Calorific basis)

Fuels\GHGs	CO_2	CH_4	N_2O
Natural Gas	56,100	1.0	0.1
Diesel	74,100	3.0	0.6
Lignite	101,000	1	1.5

- ***Activity Data***

Data were taken from the energy balances (See Annex A).

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

[51] IPCC 2006, Volume 2, table 2.2 - default emission factors for stationary combustion in the energy industries

a) Source-category description and calculated emissions

Manufacturing industries and the construction sub-sector, comprise emissions produced by the burning of fuel from various industries, such as cast iron and steel production, ferroalloys, chemicals, paper, food products, drinks and tobacco production, etc., as well as emissions from construction materials production.

After the disintegration of the Soviet Union, almost 1/3 of Georgian factories ceased production. But since 1995 the political stabilization and establishment of new industrial contacts has led to the relative stability of the main industrial indicators and GDP growth.

Heavy manufacturing industry in Georgia is one of the most important sectors in terms of value added to exports and employment. In 2018, manufacturing industries and construction sectors accounted for 10.2% and 8.3% of GDP, respectively. Together they accounted for 14% of the employment in Georgia[52]. The most important sub-sectors of heavy manufacturing are ferroalloy, steel/iron, fertilizers and cement production.

Four factories operate in the field of ferroalloys production – Georgian Manganese (the same as Zestaphoni ferroalloy factory), Chiatura Manganese[53], Rusmetal[54] and GTM Group[55]. Zestaphoni ferro-alloy factory is the largest producer of silicon-manganese. Its annual productivity is about 185,000 tons.

Steel and iron production take place in three factories - Geosteel[56], Rustavi Metallurgical Plant[57] and Iberia Steel. In this factory the steel is produced in electric ovens by melting scrap metal and slag; the biggest share (80-85%) is produced through melting scrap metal (Secondary steel production).

Fertilizers is one of the largest export products of Georgia. 'Rustavi Azoti' is the largest chemical enterprise of mineral fertilizers and industrial chemicals in Trans-Caucasus[58].

The largest company in nonmetallic building materials in Georgia - Heidelberg cement, owns three plants of cement production– one in Kaspi and two in Rustavi. Annual production capacity of the company is about 2mln tons of cement and 1.4 mln tons of clinker[59].

Emissions from fuel combustion in coke ovens within the iron and steel industry are reported under 1A1c rather than within manufacturing industry.

Table 3-12 provides GHGs emissions from the manufacturing industries and construction. GHGs emissions decreased about 7.5 times from 1990 to 2017 from the source category.

Table 3-12 GHGs Emissions from the Manufacturing Industries and Construction (Gg)

Year/Gas	CO_2	CH_4	CH4 in CO_{2eq}	N_2O	N2O in CO_{2eq}	Total in $CO_{2eq.}$
1990	7,535	0.45	9.45	0.07	21.70	**7,566**
1991	6,463	0.25	5.33	0.04	11.78	**6,480**
1992	3,851	0.14	2.86	0.02	6.20	**3,860**
1993	2,968	0.11	2.39	0.02	5.27	**2,976**
1994	2,145	0.12	2.52	0.02	5.27	**2,153**
1995	787	0.04	0.76	0.01	1.55	**790**

[52] National Statistics Office of Georgia www.geostat.ge
[53] Georgian American Alloys – www.gaalloys.com
[54] Rusmetal www.rusmetali.com
[55] Ferro-Alloy Plant www.gtmgroup.ge
[56] Geosteal www.geosteel.com.ge
[57] Rustavi Metallurgical Plant http://www.rmp.ge/en/
[58] www.rustaviazot.ge
[59] Heidelberg cement Georgia www.heidelbergcement.ge

Year/Gas	CO_2	CH_4	CH4 in CO_{2eq}	N_2O	N2O in CO_{2eq}	Total in $CO_{2eq.}$
1996	1,212	0.06	1.16	0.01	2.48	**1,216**
1997	814	0.05	1.13	0.01	2.48	**817**
1998	518	0.05	1.13	0.01	2.48	**522**
1999	289	0.05	1.03	0.01	2.17	**292**
2000	684	0.06	1.26	0.01	2.79	**688**
2001	276	0.05	1.11	0.01	2.17	**279**
2002	220	0.05	1.07	0.01	2.17	**223**
2003	243	0.05	1.09	0.01	2.17	**246**
2004	256	0.05	1.09	0.01	2.17	**259**
2005	302	0.01	0.21	0.00	0.31	**303**
2006	424	0.01	0.21	0.00	0.31	**424**
2007	482	0.01	0.23	0.00	0.31	**483**
2008	626	0.02	0.48	0.00	0.93	**628**
2009	636	0.02	0.50	0.00	0.93	**637**
2010	906	0.06	1.26	0.01	2.79	**910**
2011	1,644	0.12	2.52	0.02	5.58	**1,652**
2012	2,021	0.15	3.15	0.02	6.82	**2,031**
2013	1,505	0.13	2.77	0.02	6.20	**1,514**
2014	1,020	0.09	1.89	0.01	4.03	**1,026**
2015	1,058	0.09	1.89	0.01	4.03	**1,064**
2016	910	0.07	1.55	0.01	3.41	**915**
2017	1,010	0.08	1.70	0.01	3.72	**1,015**

According to the IPCC 2006 guidelines emissions from fuel combustion in coke ovens within the iron and steel industry should be reported under other energy industries (1A1c) rather than within manufacturing industry.

b) Methodological issues

- ***Estimation Method***

Emissions were calculated using the IPCC Tier 1 sectoral approach.

- ***Emission Factor***

Country specific net calorific values were used to convert the amount of consumed fuel from physical units into energy units (*Table 3-6*). The following default Emission Factors are provided in the *Table 3-13*[60].

Table 3-13 Default Emission Factors for Stationary Combustion in Manufacturing Industries and Construction (kg/TJ on a Net Calorific Basis)

Fuels\GHGs	CO_2	CH_4	N_2O
Natural Gas	56100	1	0.1
Diesel	74100	3	0.6
Anthracite	98300	10	1.5

[60] IPCC 2006, Volume 2, table 2.3 - default emission factors for stationary combustion in manufacturing industries and construction

Fuels\GHGs	CO_2	CH_4	N_2O
Other Bituminous Coal	94600	10	1.5
Lignite	101000	10	1.5
Liquefied Petroleum Gases	63100	1	0.1
Kerosene	71900	3	0.6
Residual Fuel Oil	77400	3	0.6
Wood/Wood Waste	112000	30	4
Other Primary Solid Biomass	100000	30	4
Coke Oven Gas	107000	10	1.5
Charcoal	112000	200	4

- ***Activity Data***

Data were taken from the energy balances (See Annex A).

3.2.6. Transport (1.A.3.)

a) Source-category description and calculated emissions

Georgia is the transportation hub for the South Caucasus region (Georgia, Armenia, and Azerbaijan) and Central Asia (Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, and Turkmenistan), providing routes to Russia, Turkey and (over the Black Sea) to Europe. Georgia's oil and gas pipelines, the Black Sea ports, developed railway system, and airports with direct air services to more than 20 destinations are also playing an increasingly important role in linking East and West.

The transport sector in Georgia, similarly to the majority of the world's countries, is one of the most significant emitters of greenhouse gases, and therefore major focus is made on the inventory of emissions from this sector and on the implementation of mitigation measures.

In Georgia, the growth of emissions from the transport sector is mainly due to several factors: annual growth of vehicle fleet, large share of second-hand cars in this fleet, and the growth of transit. Since Georgia is a transit country, the number of transit trucks consuming fuel purchased in Georgia is increasing along with the growth of local vehicles fleet. Annual growth of both local and transit transport causes the increase of carbon dioxide and other greenhouse gases, as well as local pollutants which seriously affect human health. In addition, energy transit pipelines Baku-Tbilisi-Supsa (WREP), Baku-Tbilisi-Ceyhan (BTC) oil and South Caucasus Gas (SCP) pipelines pass through the territory of Georgia. Service Company British Petroleum uses natural gas and diesel at the substations to operate the pipelines.

Under the transport sector, Georgia's GHGs Inventory includes road transport, rail transport, civil aviation, domestic navigation, and pipelines.

The trends of greenhouse gases from the transport sector are provided in *Table 3-14* and *Table 3-15*. As can be seen from the tables, similar to other source-categories of fuel combustion, carbon dioxide is the dominant greenhouse gas in this sector, accounting for 98% of the emissions in 2017.

Table 3-14 GHG Emissions from the Transport Sector (Gg)

Year/Gas	CO_2 in Gg	CH_4 in Gg	CH4 in Gg CO_{2eq}	N_2O in Gg	N2O in Gg CO_{2eq}	Total in Gg $CO_{2eq.}$
1990	3,745	0.99	20.71	0.19	57.35	**3,823**
1991	2,709	0.82	17.14	0.13	41.23	**2,767**
1992	2,305	0.62	13.02	0.11	35.34	**2,353**
1993	1,962	0.54	11.42	0.10	31.00	**2,004**
1994	1,390	0.36	7.56	0.07	21.70	**1,419**
1995	827	0.21	4.31	0.04	13.33	**845**
1996	2,455	0.99	20.87	0.12	35.96	**2,512**
1997	1,889	0.77	16.23	0.09	27.28	**1,933**
1998	1,203	0.45	9.53	0.06	17.67	**1,230**
1999	1,091	0.41	8.67	0.05	16.12	**1,116**
2000	925	0.31	6.51	0.05	13.95	**945**
2001	1,154	0.49	10.25	0.05	16.74	**1,181**
2002	1,214	0.51	10.65	0.06	17.67	**1,242**
2003	1,239	0.51	10.77	0.06	17.98	**1,268**
2004	1,203	0.47	9.79	0.06	17.67	**1,230**
2005	1,503	0.55	11.55	0.07	22.63	**1,537**
2006	1,572	0.55	11.61	0.08	23.25	**1,607**
2007	1,972	0.69	14.39	0.09	29.14	**2,016**
2008	1,685	0.60	12.64	0.08	24.80	**1,723**
2009	2,061	0.60	12.54	0.10	31.31	**2,104**
2010	2,529	0.69	14.49	0.12	35.96	**2,579**
2011	2,513	0.69	14.49	0.11	35.34	**2,563**
2012	2,617	0.70	14.70	0.13	40.61	**2,672**
2013	3,223	1.45	30.39	0.15	47.43	**3,301**
2014	3,641	1.78	37.38	0.19	57.35	**3,735**
2015	4,037	1.89	39.69	0.20	62.00	**4,139**
2016	4,547	1.89	39.63	0.23	70.99	**4,658**
2017	4,044	1.69	35.45	0.21	63.55	**4,143**

Greenhouse gases emissions by subcategories in 1990-2017 are provided by subsectors in *Table 3-15*. Road transport is the dominant subsector. (95% of the emissions in 2017). As railway transport is fully electrified effectively in Georgia, its contribution is insignificant in terms of the emissions. GHG emissions in civil aviation (during 1990-2010), domestic navigation (during 1990-2011) and other transportation sub-categories (1995, 1998-2000, 2005) are not estimated due to the lack of data.

Table 3-15 GHGs Emissions from Transport Sub-Categories (Gg CO_2 eq)

Year/Sub-categories	1A3a Civil aviation total in Gg $CO_{2eq.}$	1A3b Road Transportation total in Gg $CO_{2eq.}$	1A3c Railways total in Gg $CO_{2eq.}$	1A3d National Navigation total in Gg $CO_{2eq.}$	1A3e Other Transportation (pipelines, off road) total in Gg CO2eq.	Total from sector in Gg $CO_{2eq.}$
1990	NE	3,678	43.58	NE	101	**3,822**

Year/Sub-categories	1A3a Civil aviation total in Gg $CO_{2eq.}$	1A3b Road Transportation total in Gg $CO_{2eq.}$	1A3c Railways total in Gg $CO_{2eq.}$	1A3d National Navigation total in Gg $CO_{2eq.}$	1A3e Other Transportation (pipelines, off road) total in Gg CO2eq.	Total from sector in Gg $CO_{2eq.}$
1991	NE	2,623	43.70	NE	101	**2,767**
1992	NE	2,204	43.60	NE	106	**2,353**
1993	NE	1,935	14.46	NE	55	**2,004**
1994	NE	1,337	29.26	NE	53	**1,419**
1995	NE	844	0.89	NE	NE	**845**
1996	NE	2,506	0.04	NE	5	**2,512**
1997	NE	1,916	12.01	NE	5	**1,933**
1998	NE	1,223	7.27	NE	NE	**1,230**
1999	NE	1,116	0.04	NE	NE	**1,116**
2000	NE	945	0.04	NE	NE	**945**
2001	NE	1,171	0.00	NE	9	**1,181**
2002	NE	1,235	0.00	NE	8	**1,242**
2003	NE	1,259	1.00	NE	9	**1,269**
2004	NE	1,220	0.00	NE	10	**1,230**
2005	NE	1,537	0.00	NE	NE	**1,537**
2006	NE	1,585	1.00	NE	21	**1,608**
2007	NE	1,991	0.00	NE	25	**2,016**
2008	NE	1,695	0.00	NE	27	**1,723**
2009	NE	2,094	0.00	NE	11	**2,104**
2010	NE	2,390	0.02	NE	190	**2,580**
2011	56.2	2,291	0.00	NE	215	**2,563**
2012	1.8	2,459	3.45	4.20	204	**2,672**
2013	2.2	3,103	0.04	4.08	191	**3,301**
2014	2.5	3,500	3.76	2.19	227	**3,735**
2015	2.0	3,912	2.19	2.10	221	**4,139**
2016	3.3	4,427	3.76	2.12	222	**4,658**
2017	1.8	3,941	4.07	6.02	190	**4,143**

b) Methodological issues

- ***Estimation Method***

In the transport sector, emissions for all subcategories were calculated using the IPCC Tier 1 sectoral approach. For this sector, carbon dioxide emissions were calculated based on the consumed fuel statistics using the Tier 1 (top down) approach, since the carbon dioxide emission factor is dependent on the type of consumed fuel only, rather than the type of transport that has combusted the fuel. Methane and nitrous oxide emissions are dependent on the motor vehicle type, catalyzer type and the mode of operation, and higher-tier methods are recommended for calculating their emissions. Such detailed information is not available in Georgia; therefore, the Tier 1 sectoral approach was applied for all greenhouse gases.

- ***Emission Factor***

Country specific net calorific values were used to convert the amount of consumed fuel from physical units into energy units (Table 5). The following default Emission Factors are provided in *Table 3-16*[61].

Table 3-16 Default Emission Factors for Mobile category (kg/TJ on a Net Calorific Basis)

Fuels\GHGs	**CO_2**	**CH_4**	N_2O
Civil Aviation			
Jet Kerosene	71,500	0.5	2
Road Transportation			
Gasoline	69,300	33	3.2
Diesel	74,100	3.9	3.9
Natural Gas	56,100	92	3
LPG	63,100	62	0.2
Railways			
Sub-bituminous Coal	96,100	2	1.5
Other Petroleum Products	NA	5	0.6
Water-borne Navigation			
Diesel	74,100	7	2
Pipelines			
Natural Gas	56,100	1	0.1
Diesel	74,100	3	0.6
Off-road			
Gasoline	69,300	80	2
Diesel	74,100	4.15	28.6

- ***Activity Data***

Data are provided in the energy balances (see Annex A).

3.2.7. Other Sectors (1.A.4.)

a) Source-category description and calculated emissions

Emissions in this source-category comprise emissions from the following subsectors:

- Commercial and Public Services.
- Residential.
- Agriculture, Fishing and Forestry.

Greenhouse gases emissions from this source category are provided in *Table 3-17***.** The shares of methane (3.9% in 2017) and nitrous oxide (0.8% in 2017) are high, compared to other source categories; this is due to firewood consumption in the residential sector.

Table 3-17 GHG Emissions from The Other Sectors (Gg)

Year/Gas	**CO_2**	**CH_4**	**CH_4 in CO_{2eq}**	**N_2O**	**N_2O in CO_{2eq}**	**Total in CO_{2eq}.**
1990	5,283	5.58	117.18	0.09	26.97	**5,427**
1991	4,847	6.33	132.89	0.10	30.07	**5,010**

[61] IPCC 2006, Volume 2, table 3.2.1, 3.2.2, - Road transport default co2, ch4, n2o emission factors.

Year/Gas	CO_2	CH_4	CH_4 in CO_{2eq}	N_2O	N_2O in CO_{2eq}	Total in $CO_{2eq.}$
1992	4,686	9.35	196.27	0.13	41.54	**4,924**
1993	4,769	13.72	288.06	0.19	59.83	**5,117**
1994	2,265	4.25	89.29	0.06	18.60	**2,372**
1995	860	8.58	180.08	0.12	36.27	**1,076**
1996	937	11.96	251.16	0.16	50.53	**1,238**
1997	1,164	9.70	203.62	0.14	41.85	**1,410**
1998	1,339	8.70	182.78	0.12	37.82	**1,560**
1999	1,145	8.31	174.49	0.11	35.34	**1,355**
2000	1,228	7.88	165.52	0.11	33.48	**1,427**
2001	735	7.76	163.04	0.11	32.55	**931**
2002	560	7.74	162.58	0.10	32.24	**754**
2003	562	7.74	162.58	0.10	32.24	**757**
2004	655	7.76	162.88	0.11	32.55	**851**
2005	970	4.51	94.63	0.06	19.22	**1,084**
2006	970	4.82	101.30	0.07	20.46	**1,092**
2007	1,128	5.15	108.13	0.07	22.01	**1,258**
2008	1,252	4.96	104.18	0.07	21.08	**1,377**
2009	1,074	4.96	104.10	0.07	21.08	**1,199**
2010	1,592	5.00	104.90	0.07	20.46	**1,718**
2011	1,880	4.09	85.97	0.06	17.98	**1,984**
2012	1,748	3.89	81.71	0.05	16.74	**1,846**
2013	1,424	6.17	129.63	0.08	25.73	**1,579**
2014	1,708	6.00	125.90	0.08	25.11	**1,859**
2015	1,863	5.17	108.53	0.07	21.70	**1,993**
2016	2,079	5.04	105.82	0.07	21.39	**2,206**
2017	2,487	4.78	100.46	0.07	20.46	**2,608**

Greenhouse gas emissions by subcategories in the period of 1990-2017 are provided in *Table 3-18*. The residential sector is a dominant subsector (73% in 2017), while GHGs emissions from commercial and agricultural sub-sectors amounted to 16% and 11% respectively.

Table 3-18 GHG Emissions from Commercial/Institutional/Residential/Agriculture/Fishing/ Forestry Source-Categories, By Sub-Categories (Gg CO_2 eq)

Year/ Category	1A4a - Commercial total in $CO_{2eq.}$	1A4b - Residential total in $CO_{2eq.}$	1A4c - Agriculture/ Forestry/ Fishing total in $CO_{2eq.}$	Total from sector in $CO_{2eq.}$
1990	1,090	3,812	524	**5,427**
1991	1,107	3,046	857	**5,010**
1992	899	3,374	651	**4,924**
1993	895	3,699	523	**5,117**
1994	600	1,305	467	**2,372**
1995	126	675	275	**1,076**
1996	110	770	358	**1,238**
1997	343	733	334	**1,410**

Year/ Category	1A4a - Commercial total in $CO_{2eq.}$	1A4b - Residential total in $CO_{2eq.}$	1A4c - Agriculture/ Forestry/ Fishing total in $CO_{2eq.}$	Total from sector in $CO_{2eq.}$
1998	255	981	324	**1,560**
1999	66	1,059	230	**1,355**
2000	181	1,064	182	**1,427**
2001	69	786	76	**931**
2002	59	614	83	**755**
2003	66	628	64	**757**
2004	77	678	95	**851**
2005	124	680	280	**1,084**
2006	75	714	304	**1,092**
2007	97	774	387	**1,258**
2008	182	1,005	190	**1,377**
2009	202	832	165	**1,199**
2010	226	1,184	307	**1,717**
2011	373	1,281	330	**1,984**
2012	562	1,210	74	**1,846**
2013	270	1,278	32	**1,579**
2014	466	1,367	25	**1,859**
2015	413	1,542	38	**1,993**
2016	415	1,722	69	**2,206**
2017	419	1,895	293	**2,608**

b) Methodological issues

- ***Estimation Method***

Emissions were calculated using the IPCC Tier 1 sectoral approach.

- ***Emission Factor***

Country specific net calorific values were used to convert the amount of consumed fuel from physical units into energy units (*Table 3-6*). The following default Emission Factors are provided in the *Table 3-19*[62].

Table 3-19 Default Emission Factors for commercial/institutional and residential and agriculture/forestry/fishing categories (kg/TJ on a Net Calorific Basis)

Fuels\GHGs	CO_2	CH_4	N_2O
Commercial/Institutional			
Anthracite	98,300	10	1.5
Lignite	101,000	10	1.5
Wood	112,000	300	4
Other primary solid biomass	100,000	300	4
Natural Gas	56,100	5	0.1
LPG	63,100	5	0.1
Residual fuel oil	77,400	10	0.6
Residential			
Lignite	101,000	300	1.5
Wood	112,000	300	4

[62] IPCC 2006, Volume 2, table 2.4, 2.5

Fuels\GHGs	CO_2	CH_4	N_2O
Other primary solid biomass	100,000	300	4
Natural Gas	56,100	5	0.1
LPG	63,100	5	0.1
Other Kerosene	71,900	10	0.6
Charcoal	112,000	200	1
Agriculture/Forestry/Fishing			
Wood	112,000	300	4
Natural Gas	56,100	5	0.1
Anthracite	98,300	10	1.5
Lignite	101,000	300	1.5
Gasoline	69300	10	0.6
Diesel	74100	10	0.6
LPG	63100	5	0.1

- ***Activity Data***

Data were taken from the energy balances (See Annex A).

3.2.8. Non-Specified (1.A.5.)

Includes all remaining emissions from fuel combustion that are not specified elsewhere. The same emission factors were used here as in commercial and residential sectors.

Table 3-20 GHG Emissions from Non-specified Source-Category (Gg)

Year/Gas	CO_2	CH_4	CH_4 in CO_{2eq}	N_2O	N_2O in CO_{2eq}	Total in $CO_{2eq.}$
1990	NO	1.13	23.69	0.02	4.65	28.34
1991	NO	NO	NO	NO	NO	0.00
1992	NO	NO	NO	NO	NO	0.00
1993	NO	NO	NO	NO	NO	0.00
1994	NO	NO	NO	NO	NO	0.00
1995	NO	NO	NO	NO	NO	0.00
1996	88.17	0.01	0.19	0.00	0.00	88.36
1997	NO	NO	NO	NO	NO	0.00
1998	NO	NO	NO	NO	NO	0.00
1999	75.71	0.01	0.17	0.00	0.31	76.18
2000	NO	NO	NO	NO	NO	0.00
2001	27.49	0.00	0.04	0.00	0.00	27.53
2002	23.00	0.00	0.04	0.00	0.01	23.06
2003	26.09	0.00	0.04	0.00	0.00	26.13
2004	30.58	0.00	0.06	0.00	0.00	30.64
2005	NO	NO	NO	NO	NO	0.00
2006	12.68	0.00	0.02	0.00	0.00	12.70
2007	43.99	0.07	1.45	0.00	0.62	46.06
2008	115.79	0.07	1.55	0.00	0.62	117.97
2009	169.72	0.19	4.05	0.00	1.24	175.01
2010	240.61	0.23	4.89	0.01	1.86	247.37
2011	85.72	0.22	4.56	0.00	1.24	91.52

Year/Gas	CO_2	CH_4	CH_4 in CO_{2eq}	N_2O	N_2O in CO_{2eq}	Total in $CO_{2eq.}$
2012	0.00	0.13	2.77	0.00	0.62	3.39
2013	NO	NO	NO	NO	NO	0.00
2014	NO	NO	NO	NO	NO	0.00
2015	NO	NO	NO	NO	NO	0.00
2016	NO	NO	NO	NO	NO	0.00
2017	NO	NO	NO	NO	NO	0.00

3.2.9. Emissions from waste incineration with energy recovery

Incinerating waste for energy recovery is not carried out in Georgia.

3.3. Fugitive Emissions from Fuels (1.B.)

Fugitive emissions include all intentional or unintentional release of greenhouse gases (mainly methane) during the extraction, processing, and transportation of fossil fuels to the point of final use. Fugitive emissions were calculated from the following categories and sub-categories:

Solid fuels (coal mining and handling, underground mines)

- Coal mining
- Post-mining seam gas emissions
- Abandoned underground mines.

Oil

- Venting
- Flaring
- Oil production and upgrading
- Oil transportation
- Natural Gas
- Venting
- Flaring
- Production
- Transmission and storage
- Distribution.

GHG emissions trend from the fugitive emissions in subsectors are provided in the *Table 3-21*.

Table 3-21 Fugitive Emissions (Gg)

Year/ Category	1B1 Solid fuel total in $CO_{2eq.}$	CO_2	CH4 in CO_{2eq}	1B2a Oil total in $CO_{2eq.}$	CO_2	CH4 in CO_{2eq}	N2O in CO_{2eq}	1B2b Natural Gas total in $CO_{2eq.}$	CO_2	CH4 in CO_{2eq}	N2O in CO_{2eq}	Total fugitive emissions in $CO_{2eq.}$
1990	**738.70**	62.20	676.50	**160.46**	11.41	149.00	0.05	**5,186.87**	0.27	5,186.60	0.0005	**6,086**
1991	**23.07**	23.07	0.00	**18.06**	11.54	6.47	0.05	**5,457.83**	0.30	5,457.53	0.0005	**5,499**
1992	**8.35**	8.35	0.00	**112.19**	8.08	104.08	0.04	**4,912.87**	0.26	4,912.61	0.0004	**5,033**

Year/ Category	1B1 Solid fuel total in CO_{2eq}.	CO_2	CH4 in CO_{2eq}	1B2a Oil total in CO_{2eq}.	CO_2	CH4 in CO_{2eq}	N2O in CO_{2eq}	1B2b Natural Gas total in CO_{2eq}.	CO_2	CH4 in CO_{2eq}	N2O in CO_{2eq}	Total fugitive emissions in CO_{2eq}.
1993	**5.98**	5.98	0.00	**35.62**	2.55	33.06	0.01	**4,182.32**	0.23	4,182.09	0.0004	**4,224**
1994	**81.98**	6.90	75.08	**39.23**	2.82	36.39	0.01	**1,405.85**	0.05	1,405.80	0.0000	**1,527**
1995	**15.67**	1.32	14.35	**42.05**	3.04	39.00	0.01	**1,198.54**	0.04	1,198.50	0.0001	**1,256**
1996	**7.39**	0.62	6.77	**102.71**	3.03	99.67	0.01	**1,565.53**	0.06	1,565.47	0.0000	**1,676**
1997	**2.31**	0.19	2.11	**112.58**	8.14	104.41	0.04	**1,413.65**	0.05	1,413.60	0.0000	**1,529**
1998	**6.92**	0.58	6.33	**99.98**	7.23	92.72	0.03	**1,420.84**	0.05	1,420.79	0.0000	**1,528**
1999	**7.39**	0.62	6.77	**76.47**	5.53	70.92	0.03	**735.71**	0.03	735.69	0.0000	**820**
2000	**4.91**	0.41	4.49	**93.34**	6.75	86.56	0.03	**1,005.42**	0.15	1,005.27	0.0006	**1,104**
2001	**2.31**	0.19	2.11	**83.18**	6.01	77.14	0.03	**724.97**	0.08	724.89	0.0003	**810**
2002	**2.78**	0.23	2.54	**62.19**	4.49	57.67	0.02	**2,047.00**	0.11	2,046.89	0.0001	**2,112**
2003	**3.70**	0.31	3.38	**117.63**	8.50	109.09	0.04	**2,531.44**	0.13	2,531.31	0.0001	**2,653**
2004	**3.70**	0.31	3.38	**82.36**	5.95	76.38	0.03	**2,610.47**	0.12	2,610.35	0.0001	**2,697**
2005	**2.23**	0.19	2.04	**56.86**	4.11	52.73	0.02	**1,214.70**	0.07	1,214.63	0.0001	**1,274**
2006	**4.14**	0.35	3.79	**53.78**	3.89	49.87	0.02	**2,542.15**	0.12	2,542.02	0.0001	**2,600**
2007	**10.61**	0.89	9.72	**51.77**	3.48	48.27	0.02	**2,268.75**	0.12	2,268.63	0.0001	**2,331**
2008	**14.76**	1.24	13.51	**49.14**	3.24	45.89	0.02	**1,381.69**	0.10	1,381.59	0.0001	**1,446**
2009	**56.74**	4.78	51.96	**48.60**	3.12	45.46	0.01	**1,005.99**	0.08	1,005.92	0.0001	**1,111**
2010	**119.27**	10.04	109.23	**49.36**	3.18	46.17	0.01	**1,524.34**	0.10	1,524.24	0.0001	**1,693**
2011	**157.23**	13.24	143.99	**47.55**	3.09	44.45	0.01	**1,975.14**	0.11	1,975.03	0.0000	**2,180**
2012	**187.93**	15.82	172.11	**42.41**	2.73	39.67	0.01	**2,132.58**	0.11	2,132.47	0.0000	**2,363**
2013	**184.00**	15.20	168.80	**45.66**	2.96	42.69	0.01	**1,324.49**	0.10	1,324.39	0.0000	**1,554**
2014	**133.52**	11.23	122.29	**41.45**	2.64	38.80	0.01	**1,313.90**	0.11	1,313.78	0.0001	**1,489**
2015	**136.28**	11.47	124.80	**39.41**	2.49	36.91	0.01	**1,856.10**	0.13	1,855.97	0.0001	**2,032**
2016	**132.10**	11.12	120.98	**37.93**	2.39	35.53	0.01	**1,933.08**	0.13	1,932.95	0.0001	**2,103**
2017	**10.06**	10.06	0.00	**32.27**	1.98	30.28	0.00	**1,384.57**	0.10	1,384.47	0.0001	**1,427**

As can be seen from the table, natural gas is the dominant subsector, where high emissions are caused by high losses of natural gas in the process of transportation and distribution. Over the years, emissions from the mining and processing of coal also increased, as a result of intensification of mining of this fuel in Georgia. Below all source subcategories are described separately.

3.3.1. Solid Fuels (1.B.1.)

a) Source-category description and calculated emissions

Although mining of coal from underground layers was well developed in Georgia during the Soviet period, later coal mining decreased considerably. Starting from 2009, coal mining started to grow again and, respectively, fugitive emissions from this sub-category also increased. However, since 2017 coal mining has significantly decreased due to the technical inspection of safety norms of mines, following the deadly workplace accidents. Emissions data are provided in the *Table 3-22*.

Table 3-22 Methane Emissions from Underground Mines During Coal Mining and Treatment (Gg)

Source	1B1 Solid fuel total in $CO_{2eq.}$	1B1ai1 Mining total in $CO_{2eq.}$	1B1ai2 Post-mining seam gas emissions total in $CO_{2eq.}$	1B1ai3 Abandoned underground mines total in $CO_{2eq.}$
1990	**738.70**	637.80	100.90	0.000002
1991	**23.70**	20.81	2.89	0.000002
1992	**8.35**	7.33	1.02	0.000002
1993	**5.98**	5.25	0.73	0.000002
1994	**81.98**	70.78	11.20	0.000002
1995	**15.66**	13.53	2.14	0.000002
1996	**7.38**	6.38	1.00	0.000002
1997	**2.32**	2.00	0.32	0.000002
1998	**6.93**	5.97	0.95	0.000002
1999	**7.38**	6.38	1.00	0.000002
2000	**4.89**	4.23	0.66	0.000002
2001	**2.32**	2.00	0.32	0.000002
2002	**2.78**	2.39	0.39	0.000002
2003	**3.69**	3.19	0.50	0.000002
2004	**3.69**	3.19	0.50	0.000002
2005	**2.23**	1.93	0.30	0.000002
2006	**4.15**	3.58	0.57	0.000002
2007	**10.62**	9.16	1.45	0.000002
2008	**14.77**	12.75	2.02	0.000002
2009	**56.73**	48.99	7.74	0.000002
2010	**119.26**	102.98	16.28	0.000002
2011	**157.24**	135.76	21.48	0.000002
2012	**187.92**	162.26	25.66	0.000002
2013	**184.32**	159.14	25.18	0.000002
2014	**133.36**	115.15	18.21	0.000002
2015	**136.28**	117.66	18.62	0.000002
2016	**132.10**	114.05	18.05	0.000002
2017	**10.06**	8.83	1.23	0.000002

Coal deposits in Georgia are mainly located in three regions where coal extraction is underway for 158 years: in Tkibuli-Shaori since 1847; in Tkvarcheli since 1929 and in Akhaltsikhe since 1947[63]. Surface mining of coal is only carried out in Tkvarcheli. However, information about the volume, technology and manufacturers is not available since the entire region is occupied by Russia[64].

There are only 6 abandoned underground mines except Tkvarcheli - two in Tkibuli and four in Akhaltsikhe.

b) *Methodological issues*

- ***Estimation Method***

63 ქვანახშირის მოპოვება საქართველოში და მისი განვითარების პერსპექტივები - მწვანე ალტერნატივა / Coal Production and its Development Perspective – Green Alternative

64 ღია წესით ქვანახშირის მოპოვება საქართველოში და მასთან დაკავშირებული პრობლემები - მწვანე ალტერნატივა / Surface mining of coal in Georgia and Related Problems – Green Alternative

In all sub-sectors of solid fuel fugitive emissions were calculated using the IPCC Tier 1 sectoral approach. The Tier 1 approach requires that countries choose from the global average range of Emission Factors and use country-specific Activity Data to calculate total emissions.

Below is the general form of the equation for estimating emissions for Tier 1 approach, based on coal production Activity Data from underground coal mining and post-mining emissions:

Estimating emissions from underground coal mines for tier 1 and tier 2 approaches without adjustment for methane utilization or flaring

$$Greenhouse\ gas\ emissions = Raw\ coal\ production \times\ Emission\ factor \times Units\ convertion\ factor$$

The basic equation for estimating emissions from abandoned underground coal mines is shown below:

General equation for estimating fugitive emissions from abandoned underground coal mines

$$CH_4 emissions = Emissions\ from\ abandoned\ mines - CH_4 emissions\ recovered$$

- ***Emission Factors***

Tier 1 Emission Factors for underground mining are shown below.

Tier 1: Global Average Method – Underground Mining – prior to Adjustment for Any Methane Utilization or Flaring

$$CH_4 Emissions = CH_4 Emission\ Factor \times Underground\ Coal\ Productio \times Conversion\ Factor$$

Where units are:

Methane Emissions (Gg/year)

CH_4 Emission Factor (m^3/tons)

Underground Coal Production (tons/year)

Emission Factor:

Low CH_4 Emission Factor = 10 m^3/tons

Average CH_4 Emission Factor =18 m^3/tons

High CH_4 Emission Factor = 25 m^3/tons

Conversion Factor:

This is the density of CH_4 and converts volume of CH_4 to mass of CH_4. The density is taken at 20˚C and 1 atmosphere pressure and has a value of 0.67×10^{-6} Gg/m^3.

Countries using the Tier 1 approach should consider country-specific variables such as the depth of major coal seams to determine the emission factor to be used. As gas content of coal usually grows with increase of the depth, the low end of the range should be chosen for average mining depths <200 m, whereas the high value is appropriate for depths > 400 m. For intermediate depths, average values can be used. In Georgia, average mining depths is about 800-1200m, based on the information provided by Georgian Industrial Group (GIG), therefore High CH_4 Emission Factor = 25 m^3/tons was stated.

For a Tier 1 approach the post-mining emissions factors are shown below together with the estimation method:

TIER 1: GLOBAL AVERAGE METHOD – POST-MINING EMISSIONS – UNDERGROUND MINES

$$Methane\ emissions = CH_4 Emission \times Underground\ Coal\ Productio \times Conversion\ Factor$$

Where units are:

Methane Emissions (Gg/year)

CH_4 Emission Factor (m^3/tons)

Underground Coal Production (tons/year)

Emission Factor:

Low CH_4 Emission Factor = 0.9 m^3/tons

Average CH_4 Emission Factor =2.5 m^3/tons

High CH_4 Emission Factor = 4.0 m^3/tons

Conversion Factor:

This is the density of CH_4 and converts volume of CH_4 to mass of CH_4. The density is taken at 20˚C and 1 atmosphere pressure and has a value of 0.67×10^{-6} Gg/m^3.

Developing emissions estimates from abandoned underground coal mines requires historical records. The two key parameters used to estimate abandoned mine emissions for each mine (or group of mines) are the time (in years) elapsed since the mine was abandoned, relative to the year of the emissions inventory, and Emission Factors that take into account the mine's gassiness. Tier 1 approach includes default values and broader time intervals. For a Tier 1 approach, the emissions for a given inventory year can be calculated from the Equation below:

Tier 1 approach for abandoned underground mines

$$Methane\ Emissions = Number\ of\ Abandoned\ Coal\ Mines\ remaining\ unflooded \times Fraction\ of gassy \times Coal\ Mines\ Emission\ Factor \times Conversion\ Factor$$

Where units are:

Methane Emissions (Gg/year)

Emission Factor (m^3/year)

Note: The Emission Factor has different units here compared with the definitions for underground, surface, and post-mining emissions. The reason for this is that the different method is applied for estimating emissions from abandoned mines compared with underground or surface mining.

This equation is applied for each time interval, and emissions from each time interval are added to calculate the total emissions.

Conversion Factor:

This is the density of CH_4 and converts volume of CH_4 to mass of CH_4. The density is taken at 20˚C and 1 atmosphere pressure and has a value of 0.67×10-6 Gg/m^3.

A Tier 1 approach for determining emissions from abandoned underground mines is described below and is largely based on methods developed by the USEPA (Franklin et al, 2004).

Since six underground mines were abandoned in Georgia during 1976-2000 period, default values - percentage of coal mines that are gassy were assumed to be 30%, selected from the range 8%-100% (IPCC 2006, volume 2, table 4.1.5). As for the Emission Factors, they are obtained from the table 4.1.6 of IPCC 2006, volume 2.

- ***Activity Data***

Information about coal mining and its specificities were obtained from the National Statistics Office of Georgia (GEOSTAT).

3.3.2. Oil, Natural Gas and Other Emissions from Energy Production (1.B.2.)

a) Source-category description and calculated emissions

The sources of fugitive emissions in oil and gas systems include, but are not limited to, equipment leaks, evaporation and flashing losses, venting, flaring, incineration, and accidental releases. While some of these emission sources are engineered or intentional and therefore relatively well characterized, the quantity and composition of the emissions is generally subject to significant uncertainty due to the limited use of measurement systems. in these cases.

Fugitive emissions are calculated from the following sub-categories:

Oil

- Venting - Emissions from venting of associated gas and waste gas/vapor streams at oil facilities;
- Flaring - Emissions from flaring of natural gas and waste gas/vapor streams at oil facilities;
- Oil production and upgrading - Fugitive emissions from oil production (excluding venting and flaring) occur at the oil wellhead through to the starting point of the oil transmission system. This includes fugitive emissions related to well servicing, transportation of untreated production to treating or extraction facilities, activities at extraction and upgrading facilities, associated gas re-injection systems, and produced water disposal systems. Fugitive emissions from upgraders are grouped with those from production sites rather than those from refining facilities since the upgraders are often integrated with extraction facilities and their relative emission contributions are difficult to be established;
- Oil transportation - Fugitive emissions (excluding venting and flaring) related to the transportation of marketable crude oil to upgraders and refineries. The transportation systems may comprise pipelines, marine tankers, tank trucks and rail cars. Evaporation losses from storage, filling and unloading activities, as well as fugitive equipment leaks are the primary sources of these emissions.
- Natural Gas;
- Venting - Emissions from venting of natural gas and waste gas/vapor streams at gas facilities;
- Flaring - Emissions from flaring of natural gas and waste gas/vapor streams at gas facilities;
- Production - Fugitive emissions (excluding venting and flaring) from the gas wellhead through to the inlet of gas processing plants, or, where processing is not required, to the tie-in points on gas transmission systems. This includes fugitive emissions related to well servicing, gas gathering, processing and associated waste water and acid gas disposal activities;
- Transmission and storage - Fugitive emissions from systems used to transport processed natural gas to market. Fugitive emissions from natural gas storage systems should also be included in this category;
- Distribution - Fugitive emissions (excluding venting and flaring) during the distribution of natural gas to end users.

Table 3-23 GHG Emissions from Oil and Natural Gas Related Activities (Gg)

Source	1B2 Oil and Natural Gas total in CO_{2eq}.	1B2ai Oil venting total in CO_{2eq}.	1B2aii Oil flaring total in CO_{2eq}.	1B2aiii2 Oil production and upgrading total in CO_{2eq}.	1B2aiii3 Oil transport total in CO_{2eq}.	1B2aiii4 Oil Refining total in CO2 eq.	1B2bi Natural gas venting total in CO_{2eq}.	1B2bii Natural gas flaring total in CO_{2eq}.	1B2biii2 Natural gas production total in CO_{2eq}.	1B2biii4 Natural gas transmission and storage total in CO_{2eq}.	1B2biii5 Natural gas distribution total in CO_{2eq}.
1990	**5,347**	4.19	11.09	142.45	NO	2.60	44.88	0.08	15.10	1,476	3,651
1991	**5,476**	4.25	11.21	0.46	NO	2.10	41.88	0.08	15.11	1,006	4,395
1992	**5,025**	2.97	7.88	100.85	NO	0.49	41.35	0.07	12.47	994	3,865
1993	**4,218**	0.94	2.49	31.85	NO	0.35	33.31	0.07	12.47	810	3,326
1994	**1,445**	1.04	2.75	35.23	NO	0.21	15.99	0.00	0.66	526	863
1995	**1,241**	1.12	2.96	37.92	NO	0.05	9.80	0.01	2.63	695	491
1996	**1,668**	2.86	2.75	97.08	NO	0.03	8.58	0.00	0.83	282	1,274
1997	**1,526**	2.99	7.94	101.61	NO	0.04	7.37	0.00	0.00	243	1,164
1998	**1,521**	2.66	7.05	90.24	NO	0.04	7.52	0.00	0.00	247	1,166
1999	**812**	2.03	5.39	69.01	NO	0.05	7.24	0.00	0.00	238	490
2000	**1,099**	2.48	6.58	84.26	NO	0.02	9.49	0.11	20.36	312	663
2001	**808**	2.21	5.86	75.08	NO	0.03	8.00	0.06	10.12	263	444
2002	**2,109**	1.65	4.38	56.12	NO	0.03	6.69	0.02	4.28	220	1,816
2003	**2,649**	3.12	8.29	106.18	NO	0.04	7.60	0.03	4.69	250	2,269
2004	**2,693**	2.19	5.80	74.33	NO	0.04	8.90	0.02	3.04	293	2,306
2005	**1,272**	1.51	4.01	51.32	NO	0.02	10.46	0.03	4.69	344	856
2006	**2,596**	1.43	3.79	48.50	NO	0.02	13.58	0.03	4.69	447	2,077
2007	**2,321**	1.27	3.38	43.22	3.85	0.05	40.02	0.02	4.13	449	1,775
2008	**1,431**	1.18	3.13	40.19	4.57	0.06	65.02	0.02	3.31	351	963
2009	**1,055**	1.14	3.02	38.68	5.74	0.02	63.42	0.01	1.93	352	589
2010	**1,574**	1.16	3.08	39.41	5.72	0.00	58.12	0.01	2.07	295	1,169
2011	**2,023**	1.13	2.99	38.26	5.18	0.00	59.72	0.01	1.49	459	1,455
2012	**2,175**	0.99	2.64	33.78	5.00	0.00	60.39	0.01	1.38	485	1,586
2013	**1,370**	1.08	2.86	36.66	5.06	0.00	66.15	0.01	1.34	55	1,202
2014	**1,355**	0.96	2.55	32.66	5.29	0.00	84.75	0.01	2.63	230	996
2015	**1,896**	0.91	2.40	30.79	5.31	0.00	84.89	0.02	2.91	360	1,408
2016	**1,971**	0.87	2.31	29.53	5.15	0.07	86.14	0.01	1.69	317	1,528
2017	**1,417**	0.72	1.90	24.50	5.10	0.02	88.55	0.01	2.19	464	830

b) *Methodological issues*

- ***Estimation Method***

Fugitive emissions from oil and natural gas systems are often difficult to quantify accurately. This is largely due to the diversity of the industry, the large number and variety of potential emission sources, the wide variations in emission-control levels and the limited availability of emission-source data.

In Georgia, oil and natural gas are extracted at a small scale, and this fact has been considered in the process of the methodology selection. For assessing fugitive emissions in the course of oil extraction, the Tier 1 method was used; Tier 1 method implies the application of appropriate default Emission Factors to a representative activity parameter (usually throughput) for each applicable segment or subcategory of a country's oil and natural gas industry. Tier 1 approach is performed using equations presented below:

Tier 1: ESTIMATING FUGITIVE EMISSIONS FROM AN INDUSTRY SEGMENT

$$E_{gas,industry\ segment} = A_{industry\ segment} \times EF_{gas,industry\ segment}$$

Tier 1: TOTAL FUGITIVE EMISSIONS FROM INDUSTRY SEGMENTS

$$E_{gas} = \sum_{industry\ segments} E_{gas,industry\ segment}$$

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)

Emissions during natural gas transmission and distribution were calculated using the value of losses in the transmission and distribution systems, based on the following formula:

$$CH_4 Emissions(Gg) = Gas\ Loss(10^6\ m^3) \times Methan\ Content\ in\ Gas(\%) \times Conversion\ Factor(t\frac{CH_4}{m^3 CH_4}) \times 1000$$

This methodology corresponds to the one recommended for the calculation of emissions from natural gas losses under the Clean Development Mechanism (CDM). In the formula, a conversion factor, methane density (ρ), converts methane volume into weight. A value (0.64512 Gg CH4/mln.m3) accepted in the CDM Methodology in standard conditions (at 0°C temperature and 101.3 kPa pressure conditions), ρ= 0.0007168 (t CH_4/m^3 CH_4) was used. In total 90% was taken as the value of methane content in natural gas[65].

- ***Emission Factors***

The available Tier 1 default Emission Factors are presented in table *Table 3-24*[66]. All the presented Emission Factors are expressed in units of mass emissions per unit volume of oil or gas throughput. Furthermore, throughput statistics are the most consistently available Activity Data to be used in Tier 1 calculations. The Emission Factors apply to systems in developing countries and countries with economies in transition where there are much greater amounts of fugitive emissions per unit of activity (often by an order of magnitude or more). The reasons for the greater emissions in these cases may include less stringent design standards, use of lower quality components, restricted access to natural gas markets, and, in some cases, artificially low energy pricing resulting in reduced energy conservation.

Table 3-24 Emission Factors for Fugitive Emissions (Including Venting and Flaring) From Oil and Gas Operations

Category	Sub-Category	Emission Source	CH_4 Value	CO_2 Value	N_2O Value	Units of Measure
Gas production	All	Fugitives	1.2E-02	9.7E-05	-	Gg per mln. m3 gas production
		Flaring	8.8E-07	1.4E-03	2.5E-08	Gg per mln. m3 gas production
Gas Transmission & Storage	Transmission	Fugitives	0.64512	5.04E-06	-	Gg per mln. m3 of transported gas
		Venting	3.9E-04	5.2E-06	-	Gg per mln. m3 of marketable gas

[65] Project 2404 : Leak Reduction in Above Ground Gas Distribution Equipment in the KazTransgaz-Tbilisi Gas Distribution System- Tbilisi, Georgia

[66] From IPCC 2006, Volume 2, table 4.2.5

Category	Sub-Category	Emission Source	CH_4 Value	CO_2 Value	N_2O Value	Units of Measure
Gas Distribution	All	All	0.64512	5.73E-04	-	Gg per mln. m3 of distributed gas
Oil Production	Conventional Oil	Fugitives	3.0E-02	2.0E-03	-	Gg per 10^3 m3 conventional oil production
		Venting	8.5E-04	1.1E-04	-	Gg per 10^3 m3 conventional oil production
		Flaring	2.95E-05	4.8E-02	7.6E-07	Gg per 10^3 m3 conventional oil production
Oil Transport	Pipelines	All	5.4E-06	4.9E-07	-	Gg per 10^3 m3 oil transported by pipeline
	Tanker Trucks and Rail Cars	Venting	2.5E-05	2.3E-06	-	Gg per 10^3 m3 oil transported by Tanker Truck

- ***Activity Data***

Information about oil and natural gas production, transmission and distribution were obtained from the National Statistics Office of Georgia (GEOSTAT) and Georgian Oil and Gas Corporation (GOGC).

Assessments regarding natural gas losses were made based on the information obtained from the energy balances provided by GEOSTAT. According to the information, natural gas losses in the transportation system were about 1.49% of the domestic supply in 2017. Gas transmission losses have been assumed to be 2% of the domestic supply in previous years based on the expert judgment.

Natural gas losses are quite high in the gas distribution systems of Georgia. These losses are made up of operational (technological and accident-related) and commercial losses. The amount of losses in gas pipelines depends on several factors – gas pressure, gas pipeline diameter and length, its technical state, number of gas-control points, etc. It is almost impossible to obtain such data in Georgia.

Under the Decree N26 of November 18, 2010, the Georgian National Energy and Water Regulatory Commission, approved the Rule of Calculation of the Amount of standard losses in the natural gas distribution network. This rule is based on statistical data, expert assessments, and gas dynamics postulates. Standard losses were established for natural gas supply licenses according to this rule.

GNERC's annual reports (2012 and 2013 years), state that gas distribution losses amounted to about 9% of distributed natural gas in Georgia. This figure has been used for the calculation of gas distribution losses for the previous years in the GHGs emission inventory.

3.3.2.1. Other (Fugitive Emissions Associated with the Geothermal Power Generation) (1.B.2.d.)

In Georgia electricity is not produced with the geothermal power generation and hence there is no related fugitive emissions.

3.4. CO_2 transport and storage (1.C.)

CO_2 transport and storage do not take place in Georgia.

Chapter 4. Industrial processes and product use (CRF Sector 2)

4.1. Overview of Sector

The Chapter 4 comprises description of methodologies used for estimating GHG emissions as well as information on references to Activity Data and Emission Factors reported under CRF Sector 2 –Industrial Processes for the period 1990 to 2017.

The GHG Emissions from this sector cover emissions from the following categories: Mineral Products (2A), Chemical Industry (2B), Metal Production (2C), Non-Energy Products from Fuels and Solvent Use (2D), Electronics Industry (2E), Product Uses as Substitutes for ODS (2F) Other Product Manufacture and Use (2G) and Other Industries such as paper, drinks and food production (2H) Table *4-1*.The GHG Emissions by gases from the sector are presented in *Table* 4-2.

To the extent that confidentiality concerns allow, relative information is shown in the tables under each sub-category. Emissions by each sub-category and by gas are shown in the first table of each category.

Table 4-1 Emissions from the Industrial Processes and Product use in Georgia in 1990-2017 (Gg-CO_2 eq.)

Year	Mineral Products	Chemical Industry	Metal Production	Non-Energy Products from Fuels and Solvent Use	Electronics industry	Product Uses as Substitutes for ODS	Other Product Manufacture and Use	Other Industries such as paper, drinks and food production	Total
	2A	2B	2C	2D	2E	2F	2G	2H	
1990	572	C	2635	0	NA	NA	C	NO	3879
1991	357	C	2035	0	NA	NA	C	NO	3038
1992	211	C	1053	0	NA	NA	C	NO	1705
1993	110	C	276	0	NA	NA	C	NO	776
1994	45	C	116	0	NA	NA	C	NO	414
1995	32	C	94	0	NA	NA	C	NO	447
1996	48	C	81	0	NA	NA	C	NO	535
1997	42	C	106	0	NA	NA	C	NO	504
1998	84	C	111	0	NA	NA	C	NO	502
1999	138	C	62	0	NA	NA	C	NO	710
2000	143	C	46	0	NA	NA	C	NO	725
2001	146	C	71	0	NA	0.2	C	NO	439
2002	161	C	61	0	NA	0.9	C	NO	591
2003	161	C	111	0	NA	2.6	C	NO	699
2004	188	C	187	0	NA	5.0	C	NO	846
2005	226	C	200	0	NA	8.9	C	NO	957
2006	332	C	214	0	NA	8.7	C	NO	1136
2007	521	C	207	0	NA	9.2	C	NO	1314
2008	585	C	235	0	NA	14	C	NO	1383
2009	328	C	224	0	NA	21	C	NO	1106
2010	413	C	362	0	NA	54	C	NO	1443
2011	625	C	438	0	NA	64	C	NO	1794
2012	625	C	473	0	NA	93	C	NO	1872
2013	639	C	465	9	NA	104	C	NO	1892
2014	752	C	482	10	NA	121	C	NO	2035
2015	759	C	438	11	NA	139	C	NO	2058
2016	714	C	387	12	NA	135	C	NO	1822
2017	727	C	464	10	NA	155	C	NO	1990

Table 4-2 Emissions from the Industrial Processes and Product use by gases in Georgia in 1990-2017 (Gg)

Year	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3

			CO_2 eq.		CO_2 eq.	CO_2 eq.	CO_2 eq.		CO_2 eq.		CO_2 eq.
1990	3730	0.0433	0.9094	C	C	NA	NA	C	C	NE	NE
1991	2889	0.0208	0.4361	C	C	NA	NA	C	C	NE	NE
1992	1602	0.0107	0.2248	C	C	NA	NA	C	C	NE	NE
1993	673	0.0037	0.0773	C	C	NA	NA	C	C	NE	NE
1994	369	0.0023	0.0477	C	C	NA	NA	C	C	NE	NE
1995	388	0.0027	0.0573	C	C	NA	NA	C	C	NE	NE
1996	438	0.0020	0.0416	C	C	NA	NA	C	C	NE	NE
1997	417	0.0028	0.0586	C	C	NA	NA	C	C	NE	NE
1998	425	0.0057	0.1198	C	C	NA	NA	C	C	NE	NE
1999	576	0.0044	0.0930	C	C	NA	NA	C	C	NE	NE
2000	585	0.0036	0.0755	C	C	NA	NA	C	C	NE	NE
2001	382	0.0055	0.1155	C	C	0.22	NE	C	C	NE	NE
2002	474	0.0047	0.0986	C	C	0.86	NE	C	C	NE	NE
2003	568	0.0086	0.1803	C	C	2.64	NE	C	C	NE	NE
2004	702	0.0145	0.3035	C	C	5.01	NE	C	C	NE	NE
2005	783	0.0155	0.3254	C	C	8.91	NE	C	C	NE	NE
2006	938	0.0165	0.3474	C	C	8.71	NE	C	C	NE	NE
2007	1116	0.0160	0.3363	C	C	9.16	NE	C	C	NE	NE
2008	1178	0.0182	0.3822	C	C	13.91	NE	C	C	NE	NE
2009	892	0.0173	0.3635	C	C	20.91	NE	C	C	NE	NE
2010	1165	0.0276	0.5799	C	C	54.07	NE	C	C	NE	NE
2011	1486	0.0329	0.6907	C	C	64.20	NE	C	C	NE	NE
2012	1538	0.0354	0.7429	C	C	92.99	NE	C	C	NE	NE
2013	1542	0.0343	0.7209	C	C	104.26	NE	C	C	NE	NE
2014	1670	0.0351	0.7380	C	C	120.56	NE	C	C	NE	NE
2015	1660	0.0313	0.6574	C	C	139.38	NE	C	C	NE	NE
2016	1488	0.0024	0.0514	C	C	135.06	NE	C	C	NE	NE
2017	1606	0.0030	0.0620	C	C	155.33	NE	C	C	NE	NE

Only non-energy industrial activities related emissions are considered in this sector. Emissions due to fuel combustion in manufacturing industries are allocated to IPCC Sub-category 1A2 – Fuel Combustion Activities – Manufacturing Industries and Construction (see Chapter 3).

In 2017, total GHG emissions from this sector amounted to approximately 1,990.2 Gg-CO_2 eq., accounting for 11% of national total emissions (excluding LULUCF) in Georgia. The emissions of CO_2, CH_4, and N_2O from this sector have decreased by 53% compared to 1990. The emissions of HFCs, PFCs, SF_6, and NF_3 from this sector have increased712 times compared to 2001.

The main driving factors for the reduction of emissions in this sector since 1990 are the decrease in steel production due to economic transition.. However, HFC emissions from the product uses as ODS substitutes have largely increased. The methodological tiers used in the IPPU sector are as shown in the Table 4-3 below.

Table 4-3 The methodological tiers used in the IPPU sector

GHG Source and Sink Categories	CO_2		CH_4		N_2O			
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor		
2.A Mineral industry	D,T2	D						
2.B Chemical industry	D,T2	D,PS	NA,NO	NA,NO	D,T2	D		
2.C Metal industry	D,T2	PS	D,T1	D	NA,NO	NA,NO		
2.D Non-energy products from fuel and solvent use	D,T1	D	NA,NO	NA,NO	NA,NO	NA,NO		
2.E Electronic industry								

2.F Product uses as ODS substitutes								
2.G Other product manufacture and use								
2.H Other	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO		
GHG Source and Sink Categories	**HFCs**		**PFCs**		**SF$_6$**		**NF$_3$**	
	Method applied	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**
2.A Mineral industry								
2.B Chemical industry								
2.C Metal industry								
2.D Non-energy products from fuel and solvent use	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
2.E Electronic industry								
2.F Product uses as ODS substitutes	D,T1	D	NE	NE	NE	NE	NE	NE
2.G Other product manufacture and use	NA,NE	NA,NE	NA,NE	NA,NE	D,T1	D	NA, NE	NA,NE
2.H Other	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO

D: IPCC default, T1-T3: IPCC Tier 1-3, CS: country specific, PS: plant specific, OTH: other.

Furthermore, the chapter includes information on emissions of indirect GHGs such as non-methane volatile organic compounds (NMVOCs), carbon monoxide, nitrogen oxides (*Table 4-4*).

Table 4-4 Precursor Emissions from the Industrial Processes and Product use in Georgia in 1990-2017 (Gg)

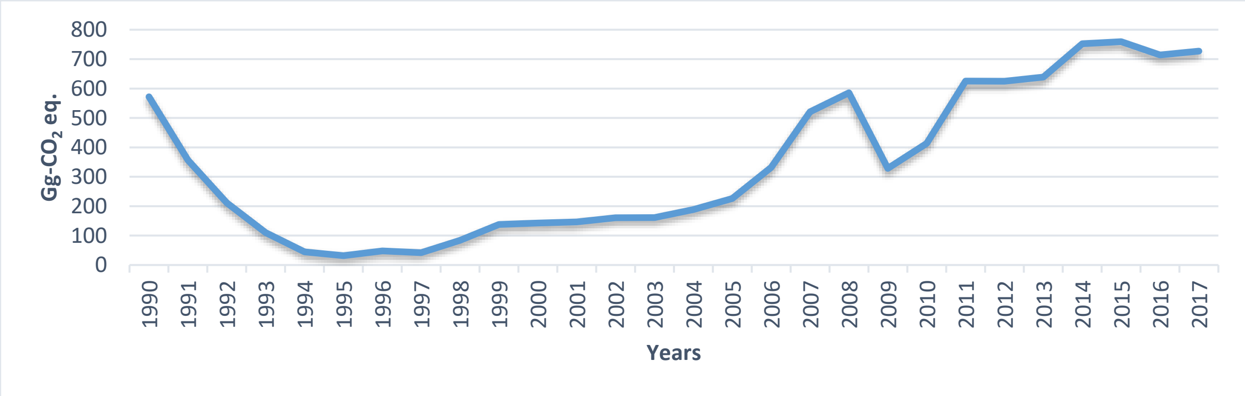
Year	CO	NOx	NMVOC	SO$_2$	Year	CO	NOx	NMVOC	SO$_2$
1990	1.6	2.85	11.92	0.40	2004	1.0	2.69	2.04	0.13
1991	1.5	2.86	12.93	0.26	2005	1.2	3.19	2.16	0.17
1992	0.9	1.98	9.22	0.14	2006	1.4	3.67	2.29	0.25
1993	0.8	1.99	7.65	0.07	2007	1.4	3.65	2.41	0.39
1994	0.4	0.86	5.92	0.03	2008	1.5	3.68	2.02	0.42
1995	0.5	1.12	3.79	0.02	2009	1.4	3.72	2.22	0.27
1996	0.7	1.86	3.38	0.03	2010	1.6	4.33	2.87	0.28
1997	0.0	1.67	2.25	0.03	2011	1.7	4.69	3.29	0.46
1998	0.6	1.49	2.31	0.06	2012	1.8	4.65	3.22	0.47
1999	1.0	2.59	1.90	0.10	2013	1.7	4.73	3.34	0.50
2000	1.1	2.71	1.90	0.10	2014	1.7	4.72	3.58	0.50
2001	0.5	1.08	1.27	0.10	2015	1.9	4.99	3.59	0.54
2002	0.9	2.25	1.52	0.10	2016	1.5	3.85	3.81	0.56
2003	1.0	2.48	1.64	0.10	2017	1.7	4.43	4.10	0.63

4.2. Mineral Industry (2.A.)

The Sub-sector of the mineral products considers the direct GHG emissions from the Cement Production (2.A.1), Lime Production (2.A.2) and Glass Production (2.A.3) source-categories. The non-direct GHG emission was additionally estimated for the source category of Asphalt Processing. In 2017 the GHG emissions from the sub-sector of the mineral products was 37% of total emissions from the Industrial Processes and Product use.

The highest emissions from the sub-sector of mineral products were estimated in 2015; it was about 759 Gg-CO_2 eq. mainly caused by performance improvement in clinker production. The emissions value at the end of estimation period (727 Gg-CO_2 eq. in 2017) was 21% higher than the value estimated in 1990 (571 Gg-CO_2 eq.). Other peaking years of emissions were 2008 and 2011. The emissions from the sub-sector have significantly declined since1990 for next five years. Although the production processes of all three categories have been reduced, the steep depletion of the GHG emission is mainly related to the sharp decline of clinker production. The recovery of the construction markets for chemical industries has taken more than a decade. The transformation period was characterized with a few crises in economic development translated into the lowest level of GHG emissions from the sub-sector. The collapse of socialist system has resulted in the reduction of production of construction goods more than twenty times. In 1995 the emissions dropped by 95% comparing to the 1990 level and reached its lowest level for the whole time series period - 32 Gg-CO_2 eq. The emissions have declined from 2008 to 2009 due to the economic crisis in the construction market in Georgia. The emissions have increased between 2009- and 2015-years period by approximately 57%. The largest upturn was recorded in 2009-2011years period from 328 to 625 Gg-CO_2 eq. Afterwards, the emissions have steadily increased by 2%. At the end of the period the emissions have dropped by 6%, comparing the value calculated for the year of 2015. The emissions trend is illustrated in the Figure 4-1 beneath.

Figure 4-1 GHG Emissions from mineral production



4.2.1. Cement Production (2.A.1.)

a) Source-category description and calculated emissions

CO_2 is emitted in the process of the calcination of limestone, the main component of which is calcium carbonate, during the production of clinker - an intermediate product of cement, the main component of which is calcium oxide.

The clinker in Georgia is produced by two different methods called dry and wet methods in three factories. The dry method is used in Rustavi Factory, while the wet method is used both in Rustavi and Kaspi factories.

In 2014 the emissions reached the highest value for the whole time series. In 2016 the emissions declined by 10 per cent[67]. The emissions estimated for the year of 1990 were about 29 %lower than in 2014. Following five years the emissions trend was declining. During the two decades since the restitution of independence of Georgia there was another low production level identified due to the economic crisis. In 2009 the emissions dropped by 48% compared to the 2008 level and y 43%compared to the 1990 level mainly caused by the economic crisis in the international market. The emissions during 2009-2015 have increased by 146%. In 2017 the emissions from the clinker production were about 8% lower compared to 2014, since the production slightly slowed down due to the market saturation.

2A1 - Cement Production is a key source-category regarding CO_2 emissions. It has been a key source without interruption since 1990: see Table 1-2

[67]The value was calculated based on the date expressed in thousandths

The calculated CO_2 emissions from the clinker production are presented in Table 4-5 beneath.

Table 4-5 CO_2 emissions from clinker production (Gg) in 1990-2017

Year	Quantity of Clinker or Cement Produced (t)	Emission Factor (t CO_2/t clinker or cement produced)	CKD Correction Factor	CO_2 Emitted (t)	CO_2 Emitted (Gg)
1990	C	0.51025	1.02	C	C
1991	C	0.51025	1.02	C	C
1992	C	0.51025	1.02	C	C
1993	C	0.51025	1.02	C	C
1994	C	0.51025	1.02	C	C
1995	C	0.51025	1.02	C	C
1996	C	0.51025	1.02	C	C
1997	C	0.51025	1.02	C	C
1998	C	0.51025	1.02	C	C
1999	C	0.51025	1.02	C	C
2000	C	0.51025	1.02	C	C
2001	C	0.51025	1.02	C	C
2002	C	0.51025	1.02	C	C
2003	C	0.51025	1.02	C	C
2004	C	0.51025	1.02	C	C
2005	C	0.51025	1.02	C	C
2006	C	0.51025	1.02	C	C
2007	C	0.51025	1.02	C	C
2008	C	0.51025	1.02	C	C
2009	C	0.51025	1.02	C	C
2010	C	0.51025	1.02	C	C
2011	C	0.51025	1.02	C	C
2012	C	0.51025	1.02	C	C
2013	C	0.51025	1.02	C	C
2014	C	0.51025	1.02	C	C
2015	C	0.51025	1.02	C	C
2016	C	0.51025	1.02	C	C
2017	C	0.51025	1.02	C	C

The calculated emissions of Sulfur dioxide from the cement production are shown in the *Table 4-6* beneath.

Table 4-6 SO_2 emissions (Gg) from cement and clinker production in 1990-2017

Year	Quantity of Cement Produced (Gg)	Emission Factor (t SO_2 /Gg cement produced)	SO_2 Emitted (t)	SO_2 Emitted (Gg)
1990	1290	0.3	387.0	0.39
1991	821	0.3	246.3	0.25
1992	451	0.3	135.2	0.14
1993	227	0.3	68.3	0.07
1994	89	0.3	26.6	0.03
1995	59	0.3	17.7	0.02
1996	85	0.3	25.5	0.03
1997	94	0.3	28.2	0.03
1998	199	0.3	59.6	0.06
1999	341	0.3	102.4	0.10
2000	348	0.3	104.3	0.10
2001	335	0.3	100.6	0.10
2002	347	0.3	104.0	0.10
2003	345	0.3	103.4	0.10
2004	442	0.3	132.5	0.13
2005	530	0.3	158.9	0.16
2006	790	0.3	236.9	0.24

Year	Quantity of Cement Produced (Gg)	Emission Factor (t SO_2 /Gg cement produced)	SO_2 Emitted (t)	SO_2 Emitted (Gg)
2007	1264	0.3	379.1	0.38
2008	1351	0.3	405.3	0.41
2009	870	0.3	261.1	0.26
2010	907	0.3	272.1	0.27
2011	1502	0.3	450.6	0.45
2012	1546	0.3	463.7	0.46
2013	1619	0.3	485.6	0.49
2014	1619	0.3	485.6	0.49
2015	1759	0.3	527.6	0.53
2016	1844	0.3	553.2	0.55
2017	2058	0.3	617.3	0.62

b) *Methodological issues*

- ***Estimation Method***

CO_2 emissions from cement production are estimated using the IPCC 2006 Tier 2 approach. In accordance with the Tier 2 method CO_2 emissions can be calculated from based on the clinker production:

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

Where:

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

The Cement Kiln Dust (CDK) Correction Factor equals to 1.02.
The emission factor calculation is represented beneath:

$$EF_{cl} = 0.785 \times 0.65^* = 0.51025$$

** The default value of the CaO content for clinker*

- ***Emission factors***

According to the IPCC 2006 emission factor is calculated as follows: EF = CaO fraction × 0.785 (molecular weight ratio of CO_2 / CaO = 44.01 / 56.08). The default value of the CaO content in clinker is equal to 65%. Accordingly, EF = 0.65 × 0.785 = 0.51025 t CO_2 /t clinker. For clinker EF = 0.51 CO_2 tonne / tonne of produced clinker[68].

In this sub-sector sulfur dioxide (SO_2) emissions are also calculated, according to the IPCC 1996 its emission rate is 0.3 kg of SO_2 / tonne of product.

- ***Activity data***

In Georgia, three clinker production plants operate (two plants in Rustavi City and One in Kaspi City). During the production of clinker, limestone, which is mainly calcium carbonate ($CaCO_3$), is calcined to produce lime (CaO) and CO_2 as a by-product.

[68] 2006 IPCC Guidelines for National Greenhouse Gas Inventories. http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

Activity data – figures of clinker production is obtained from the Factories. All three factories are owned by one company. Accordingly, the production data are confidential (*Table 4-7*).

Table 4-7 The Activity Data of Clinker Production

Clinker Production					
Year	**Activity Data (t)**	**Year**	**Activity Data (t)**	**Year**	**Activity Data (t)**
1990	C	2000	C	2010	C
1991	C	2001	C	2011	C
1992	C	2002	C	2012	C
1993	C	2003	C	2013	C
1994	C	2004	C	2014	C
1995	C	2005	C	2015	C
1996	C	2006	C	2016	C
1997	C	2007	C	2017	C
1998	C	2008	C		
1999	C	2009	C		

c) Uncertainties and Time-series Consistencies

- ***Uncertainty***

The default value given in the 2006 IPCC Guidelines was applied for the uncertainty of the CO_2 emission factor and activity data for cement production. As a result, the uncertainty of emissions was estimated to be 4%.

- ***Time-series Consistency***

Georgia applies for tier 2 method for estimation of GHG emissions from cement production. clinker production data delivered from three factories cover the period of 2008 to 2017. To keep time-series consistency since the activity data at the factory level are available since 2008, CO_2 emissions from cement production between the years 1990 and 2007 is estimated by using overlap method. The cement production data series have been applied as previously used method for estimation of emissions from clinker production between the years 1990 and 2007.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. General inventory QC focuses on checking of the parameters for activity data and emission factors and archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculations have not been applied for this submission.

f) Category-specific Planned Improvements

Georgia is going to advance these assumptions by addressing its national circumstances and to provide relevant information in its forthcoming submissions in accordance with the study of the source-category under the project: "Georgia's Integrated Transparency Framework for Implementation of Paris Agreement".

4.2.2. Lime Production (2.A.2.)

a) Source-category description and calculated emissions

CO_2 is emitted during the calcination of $CaCO_3$, $MgCO_3$ in limestone used as raw material to produce quicklime.

In 2014 the emissions were about 31 Gg CO_2 the lowest value for the recent five years. In 2016 the emissions increased by 49 per cent[69] to 60 Gg CO_2. with highest emissions from the Lime Production in Georgia during the whole time series for the period of 1990 to 2017. In 2017 the emissions dropped approximately by12 per cent. The emissions estimated for the year of 1990 (37 Gg CO_2) were about 21% lower than in 2017. Following four years the emissions trend was descending and it reached the level of 1.3 Gg CO_2 (depletion by 63 per cent). During the two decades since the restitution of independence of Georgia another low production level has occurred due to the economic crisis. In 1997 the emissions dropped by 148 times compared to 1996-year level mainly caused by the economic crisis in the country. In 2004 the emissions dropped by 55% compared to the previous year estimation resulted by the economic changes in the country. In 2008 the growth of Lime production was stopped due to the war, accordingly the emissions slightly declined -by 14% (17 Gg CO_2) compared to the 2007-year level. The international market crisis has not significantly affected the Lime Production sector since the goods produced are mostly used domestically. In 2009 the emissions reached 40 Gg CO_2. The increase of CO_2 emissions is 57% higher than in 2008.

The calculated carbon dioxide emissions from lime production in Georgia are presented in the *Table 4-8* beneath.

Table 4-8 CO_2 emissions from lime production in 1990-2017

Year	Quantity of Lime Produced (t)	Emission Factor (t CO_2/t Quicklime produced)	LKD	Water correction factor	CO_2 Emitted (t)	CO_2 Emitted (Gg)
1990	49,400.00	0.75	1.02	0.97[70]	36,657.3	36.66
1991	18,500.00	0.75	1.02	0.97	13,727.9	13.73
1992	11,100.00	0.75	1.02	0.97	8,236.8	8.24
1993	5,000.00	0.75	1.02	0.97	3,710.3	3.71
1994	1,800.00	0.75	1.02	0.97	1,335.7	1.34
1995	4,300.00	0.75	1.02	0.97	3,190.8	3.19
1996	14,800.00	0.75	1.02	0.97	10,982.3	10.98
1997	100.00	0.75	1.02	0.97	74.2	0.07
1998	3,200.00	0.75	1.02	0.97	2,374.6	2.37
1999	400.00	0.75	1.02	0.97	296.8	0.30
2000	3,100.00	0.75	1.02	0.97	2,300.4	2.30
2001	13,300.00	0.75	1.02	0.97	9,869.3	9.87
2002	26,300.00	0.75	1.02	0.97	19,515.9	19.52
2003	27,600.00	0.75	1.02	0.97	20,480.6	20.48
2004	12,400.00	0.75	1.02	0.97	9,201.4	9.20
2005	16,400.00	0.75	1.02	0.97	12,169.6	12.17
2006	22,200.00	0.75	1.02	0.97	16,473.5	16.47
2007	23,790.00	0.75	1.02	0.97	19,546.6	19.55
2008	22,390.78	0.75	1.02	0.97	33,504.2	33.50
2009	28,241.83	0.75	1.02	0.97	39,707.1	39.71
2010	14,954.11	0.75	1.02	0.97	32,251.4	32.25
2011	33,610.48	0.75	1.02	0.97	46,128.3	46.13
2012	8,438.37	0.75	1.02	0.97	29,314.0	29.31
2013	13,238.62	0.75	1.02	0.97	33,328.4	33.33

[69]The value was calculated based on the data expressed in thousands

[70]In case of factory specific data, the water correction factor equals to 0.986

Year	Quantity of Lime Produced (t)	Emission Factor (t CO_2/t Quicklime produced)	LKD	Water correction factor	CO_2 Emitted (t)	CO_2 Emitted (Gg)
2014	20,058.47	0.75	1.02	0.97	30,831.2	30.83
2015	37,259.64	0.75	1.02	0.97	45,857.3	45.86
2016	54,691.60	0.75	1.02	0.97	60,654.4	60.65
2017	41,939.00	0.75	1.02	0.97	53,385.2	53.39

2A2 – Lime Production is a key source-category regarding CO_2 emissions. It has been a key source since 2002. see Table 1-2

b) Methodological Issues

- ***Estimation Method***

In accordance with the GPG 2000 the CO_2 emissions from the Lime production is calculated based on the following equation:

$$CO_2 Emissions = M_l \times EF_l \times CF_{ckd} \times CF_w$$

Where:

M_l = weight (mass) of lime produced, tonnes
EF_l= emission factor for lime, tonnes CO_2/tonne lime (0.75)
CF_{lkd} = emissions correction factor for LKD, dimensionless (1.02)
CF_w = water correction factor (0.97)
CF_w = factory specific water correction factor (0.986)

- ***Emission factors***

In theory, assuming that calcination of the raw material is 100%, the emission factor for lime is equal to 785 kg of CO_2 per a tonne of lime. Furthermore, since the wet production technology is used to produce the largest amount of lime in Georgia the default hydrated lime correction factor of 0.97 was used in calculations.

- ***Activity data***

A major producer of lime in Georgia is JSC "Heidelberg Cement." It owns approximately 72% of the lime production in Georgia. In Georgia lime is also produced by several small enterprises, such as small plants in Kutaisi, Surami, Dzirula, Ozurgeti, and Zugdidi. All of them mainly use limestone as raw material. There is no accurate statistics on data of consumed raw materials. According to data supplied by a manufacturer[71] approximately 1.75 tons of raw materials is needed to produce 1 tonne of lime. Production technology is mostly based on the wet method.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor, the default value of 2% in the 2006 IPCC Guidelines was used. For the uncertainty of activity data, the default value of 3% in the 2006 IPCC Guidelines was used. As a result, the uncertainty for emissions was estimated as 4%.

[71] industria_kiri@posta.ge; contacts@rustavisteel.com

- ***Time-series Consistency***

Lime production data at an aggregated level have been provided by the Statistics Office of Georgia. Since 2007 one factory has been providing factory specific activity data. Accordingly, in order to avoid any double counting the amount of produced lime from the reported factory has been deducted from the aggregated data delivered by the Statistics office of Georgia.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the2006 IPCC Guidelines. General inventory QC focuses on checking the parameters for activity data and emission factors and archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculations have not been applied for this submission.

f) Category-specific Planned Improvements

Georgia is going to advance these assumptions by addressing its national circumstances and to provide relevant information in its forthcoming submissions in accordance with the study of the source-category under the project: “Georgia’s Integrated Transparency Framework for Implementation of Paris Agreement”.

4.2.3. Glass production (2.A.3.)

a) Source-category description and calculated emissions

Limestone contains $CaCO_3$ and minute amounts of $MgCO_3$; dolomite contains $CaCO_3$ and $MgCO_3$. Heating of limestone and dolomite releases CO_2 derived from $CaCO_3$ and $MgCO_3$. Similarly, CO_2 is emitted from soda ash, barium carbonate, potassium carbonate, strontium carbonate, and lithium carbonate.

This subcategory implies productions and technologies, related to thermal processing of carbonate. One of such technologies is in the glass production. The CO_2 emissions from the glass production are included in this category.

The emissions from the source-category of Glass Production are rather low in Georgia. In 2017 the emissions were about C Gg CO_2. In 2015 the emissions increased by 9.7%[72] to C Gg CO_2. Since 2012 the emissions gradually increased to the end of the calculation period. The highest emissions from the Glass production in Georgia were noted in 1990 - C Gg of CO_2 during the whole time series from 1990 to 2017. During next four years there was downward emissions trend and it reached the level of C Gg CO_2 (depletion by 88 %). The lowest level of emissions was estimated in 2009 - about 2 Gg CO_2 due to the war. Afterwards the emitted amount of CO_2 has increased steadily and at the end of the estimation period it was 86% higher compared to the year of 2009.

The calculated quantities of emitted NMVOCs and CO_2 from glass production of Georgia are presented in Table 4-9 and *Table 4-10*.

Table 4-9 CO_2 emissions from glass production

[72]The value was calculated based on the data expressed in thousands

Year	Glass production (t)	EF of glass production (t CO_2/t glass)	Cullet (ratio)	CO2 emission (t)	CO2 emission (Gg)
1990	C	0.21	NE	C	C
1991	C	0.21	NE	C	C
1992	C	0.21	NE	C	C
1993	C	0.21	NE	C	C
1994	C	0.21	NE	C	C
1995	C	0.21	NE	C	C
1996	C	0.21	NE	C	C
1997	C	0.21	NE	C	C
1998	C	0.21	NE	C	C
1999	C	0.21	NE	C	C
2000	C	0.21	NE	C	C
2001	C	0.21	NE	C	C
2002	C	0.21	NE	C	C
2003	C	0.21	0.70	C	C
2004	C	0.21	0.65	C	C
2005	C	0.21	0.65	C	C
2006	C	0.21	0.70	C	C
2007	C	0.21	0.65	C	C
2008	C	0.21	0.70	C	C
2009	C	0.21	0.70	C	C
2010	C	0.21	0.70	C	C
2011	C	0.21	0.65	C	C
2012	C	0.21	0.70	C	C
2013	C	0.21	0.65	C	C
2014	C	0.21	0.65	C	C
2015	C	0.21	0.65	C	C
2016	C	0.21	0.91	C	C
2017	C	0.21	0.91	C	C

Table 4-10 NMVOCs emissions from glass production in 1990-2017

Year	Glass production (Gg)	Emission factor (t NMVOCs /Gg glass)	NMVOCs emissions (t)	NMVOCs emissions (Gg)
1990	C	NE	NE	C
1991	C	NE	NE	C
1992	C	NE	NE	C
1993	C	NE	NE	C
1994	C	NE	NE	C
1995	C	NE	NE	C
1996	C	NE	NE	C
1997	C	NE	NE	C
1998	C	NE	NE	C
1999	C	NE	NE	C
2000	C	NE	NE	C
2001	C	NE	NE	C
2002	C	NE	NE	C
2003	C	4.5	177.1	C
2004	C	4.5	205.3	C
2005	C	4.5	217.3	C
2006	C	4.5	191.9	C
2007	C	4.5	209.0	C
2008	C	4.5	152.7	C

Year	Glass production (Gg)	Emission factor (t NMVOCs /Gg glass)	NMVOCs emissions (t)	NMVOCs emissions (Gg)
2009	C	4.5	63.3	C
2010	C	4.5	85.4	C
2011	C	4.5	117.4	C
2012	C	4.5	106.7	C
2013	C	4.5	130.4	C
2014	C	4.5	228.9	C
2015	C	4.5	253.6	C
2016	C	4.5	304.8	C
2017	C	4.5	356.1	C

2A7 – Glass Production is not a key source-category regarding CO_2 emissions. It has been a key source since 2003. see Table 1-2

b) Methodological Issues

- ***Estimation Method***

The IPCC 1996 methodology was used, according to which, only NMVOCs emissions from this sub-sector will be considered. Since 2006 the IPCC methodology also includes the CO_2 emissions Three levels are used for the calculation purposes. Based on the Tier 1 approach CO_2 emissions are calculated by the following formula:

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

Where:

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

Estimation of NMVOCs emission is carried out by multiplying emission factor (tonnes of NMVOCs emitted from glass production) by the number of tonnes of glass produced during the year.

- ***Emission factors***

NMVOCs emission is determined by the weight of melted glass mass. A similar blend composition is mainly used at a plant and the glass is produced using the same technology. The IPCC 1996 Methodology proposes emission coefficient of 4.5 kg of NMVOCs / tonne of produced glass.

The IPCC 2006 methodology provides CO_2 emission factor - 0.21 tonne of CO_2 / a tonne of glass, which is exactly the same value of the CO_2 emission coefficient calculated on the basis of chemical composition of glass blend, used at Ksani plant (a tonne of raw materials produces 0.85 tonne of glass and the mass loss is about 17.85%, so the emission coefficient is 0.17 / 0.85 = 0.21 tonne of CO_2 / a tonne of produced glass).

- ***Activity data***

In Georgia, the glass production is run by JSC “Mina” - Ksani glass factory, located in Mtskheta region, in Ksani. Currently the plant uses 4 recipes of blend for green, antique green, blue and light green glass bottle making. Ksani glass factory started its activities in 1987 with 3 furnaces and 8 production lines and its annual capacity was 40 thousand tonnes. during the period of 1992-97 due to the ongoing processes in the country the plant's capacity was reduced to a single oven. In 1997, the Turkish industrial holding "Shishejam" bought the plant’s control package of shares and the plant’s capacity increased up to 18 thousand tonnes. At the end of 2002, the second furnace was launched with 2 production lines and the plant's capacity became 48 thousand tonnes / year. In 2008, the first furnace stopped working due to the lapse of the operational life. Presently the second furnace is operating, and the plant capacity is 35 thousand tonnes / year.

The activity data and the cullet content data was provided by the Ksani Glass Factory for the years of 2003 -2015 (*Table 4-11*).

Table 4-11 The activity data of glass production

Glass Production					
Year	**Activity Data (t)**	**Year**	**Activity Data (t)**	**Year**	**Activity Data (t)**
2003	C	2008	C	2013	C
2004	C	2009	C	2014	C
2005	C	2010	C	2015	C
2006	C	2011	C	2016	C
2007	C	2012	C	2017	C

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The default value of 5% provided in the 2006 IPCC Guidelines was applied for the uncertainty of the emission factor. The default value of 3% provided in the 2006 IPCC Guidelines was applied for the uncertainty of activity data. As a result, the uncertainty for emissions was estimated as 6%.

- ***Time-series consistency***

Georgia applies for tier 1 method for estimation of GHG emissions from glass production. Glass production data has been delivered by the factory for the period of 2003 to 2017. To keep time-series consistency, as the activity data at the factory level is only available since 2003, CO_2 emissions from glass production between 1990 and 2002 were estimated by using overlap method. The bottle consumption data series have been applied as previously used method for estimation of emissions from glass production between 1990 and 2003.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the 2006 IPCC Guidelines. General inventory QC focuses on checking of the parameters for activity data and emission factors and archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculations have not been applied for this submission.

f) Category-specific Planned Improvements

Georgia is going to advance these assumptions by addressing its national circumstances and to provide relevant information in its forthcoming submissions in accordance with the study of the source-category under the project: "Georgia's Integrated Transparency Framework for Implementation of Paris Agreement".

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

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

The ceramic production is the only one from this source category, carried out in Georgia; this production is characterized as carbon free process in accordance to the laboratory analysis provided by the plant.

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

This source category does not exist in Georgia.

4.2.4.3. Non-metallurgical magnesium production (2.A.4.c)

This source category does not exist in Georgia.

4.2.4.4. Other (2.A.4.d)

This source category does not exist in Georgia.

4.3. Chemical Industry (2.B.)

The Sub-sector of the chemical industry in Georgia considers emissions from the Ammonia Production (2.B.1) and Nitric Acid Production (2.B.2) source-categories. In 2017 the GHG emissions from the sub-sector of the chemical industry amounted to 32% of the total emissions from the Industrial Processes and Product use.

The highest emissions from the sub-sector of chemical industry was estimated in 2015 - about C Gg of CO_2 eq., mainly caused by performance improvement in both production lines. In 2016 the emissions declined by 19% followed by 10% increase in 2017. The emissions value at the end of the estimation period was 4.65% higher than the value estimated in 1990 (C Gg-CO_2 eq.). 1996, 2000 and 2007 were also peaking years of emissions. The emissions from the sub-sector have significantly declined since 1990 during next four years. Although the production processes of both chemicals have been reduced, the steep depletion of the GHG emission is mainly related to the sharp cut of number of ammonia customers. Seeking new markets for chemical industries has taken more than a decade. The transformation period was characterized with a few crises in economic development translated into the lowest level of GHG emissions from the sub-sector. The collapse of socialism system has caused the reduction of production of chemical goods more than twice. In 1994 the emissions dropped by 62% compared to the 1990 level. In 2001 the emissions reached its lowest level for the whole time series period - C Gg-CO_2 eq. (only 33% of 1990 level). The emissions declined from 2008 to 2010 due to the economic crisis in the industry market. The emissions increased between 2010 and 2015 period by approximately 15%. The largest upturn was recorded in 2011 from C Gg to C Gg- CO_2 eq. Later, the emissions slightly declined (by 1.6%) due to the decrease in production of nitric acid. At the end of the period the emissions increased again by 6% compared to the value calculated for the year of 2014. The emissions trend is illustrated in the

Figure 4-2 GHG Emissions from Chemical Industry

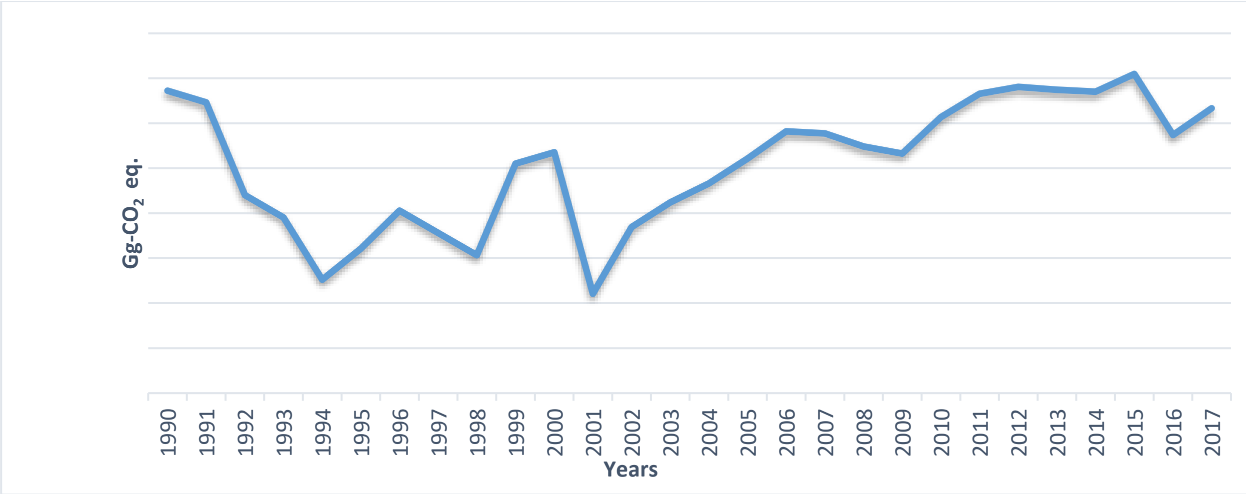
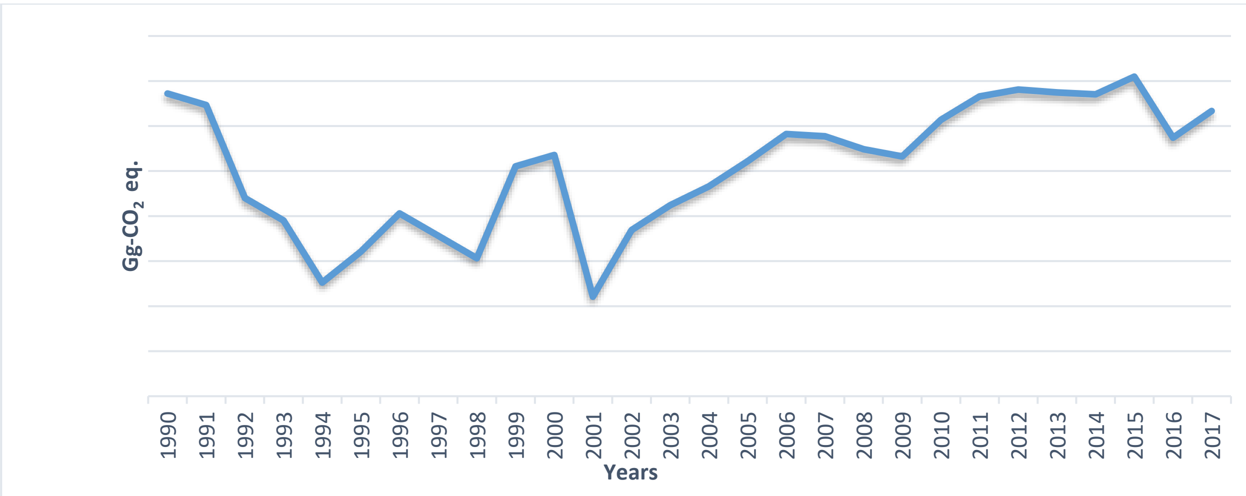


figure beneath.

Figure 4-2 GHG Emissions from Chemical Industry



4.3.1. Ammonia Production (2.B.1.)

a) Source-category description and calculated emissions

In ammonia production, CO_2 is emitted when hydrocarbon feedstock is broken down for producing H_2.

Most of the ammonia in Georgia is produced through the Haber-Bosch process called a synthesis of ammonia: nitrogen and hydrogen enter into a reaction. The required hydrogen is a product of natural gas conversion.

Ammonia is obtained at 25-29 MPa pressure and 470-550° C temperature from nitrogen and hydrogen mixture with iron catalyst in place.

The carbon dioxide resulted from the production of ammonia has been used for obtaining the dry ice. Taking into account the fact that the solid carbon dioxide almost immediately coverts into atmosphere gas after dry ice is used, the intermediate retention of CO_2 in products and production processes will not be considered.

In 2015 the emissions were about C Gg CO_2, the highest value since 1991. In 2016 the emissions declined by 17 % followed by 7 % increase in 2017. In 2014 the emissions slightly dropped (by 0.87 per cent)[73] - from C Gg CO_2 to C Gg CO_2. The highest emissions were estimated in 1990 - about C Gg CO_2. During next four years the emissions trend was descending and it reached the level of C Gg CO_2 (depletion by 60.38%). During the first decade after the restitution of independence of Georgia there were two more times when the production levels reached their minimum due to the economic crisis. In 1998 the emissions dropped by 56% (C Gg CO_2) compared to the 1990 level and in 2001 the emission level was reduced by 69% compared to the 1990 emission estimation. The emissions declined by 12%[74] since 2007 for two years mainly due to the economic crisis in the international market. The emissions have increased from C Gg CO_2 (in 2009) up to C (in 2015) by 33%.

Table 4-12 CO_2 emissions from the ammonia production calculated on the basis of products quantity in 1990-2017

Year	Total natural gas requirement (Gj)	Carbon content factor of the natural gas (kg C/GJ)	carbon oxidation factor of the natural gas (fraction)	CO_2 recovered for downstream use (kg)	CO_2 Emitted (Gg)
1990	C	143,120,974	1[75]	1	C
1991	C	136,052,006	1	1	C
1992	C	92,235,615	1	1	C
1993	C	78,466,560	1	1	C
1994	C	56,705,411	1	1	C
1995	C	71,765,384	1	1	C
1996	C	84,481,522	1	1	C
1997	C	73,644,584	1	1	C
1998	C	62,807,646	0.9981	1	C
1999	C	103,072,457	0.9963	1	C
2000	C	108,739,284	0.9916	1	C
2001	C	45,199,898	0.9970	1	C
2002	C	69,148,138	0.9981	1	C
2003	C	80,822,499	0.9984	1	C
2004	C	89,538,650	0.9964	1	C
2005	C	97,726,551	0.9956	1	C
2006	C	107,393,555	0.9966	1	C
2007	C	107,067,960	0.9900	1	C
2008	C	98,510,924	0.9915	1	C
2009	C	94,366,870	0.9834	1	C
2010	C	108,253,165	0.9837	1	C
2011	C	117,287,868	0.9842	1	C
2012	C	120,595,044	0.9970	1	C
2013	C	118,539,665	0.9903	1	C
2014	C	119,054,086	0.9774	1	C
2015	C	124,961,924	0.9866	1	C
2016	C	104,058,266	0.9830	1	C
2017	C	111,947,336	0.9850	1	C

The value was calculated based on the data expressed in thousands

[74]The comparison of the emission levels between the years of 2007 and 2009.
[75]The default data is used due to the absence of the factory specific data

Table 4-13 NMVOCs, CO and SO_2 reflects emissions from ammonia production calculated for 2010-2011 years period.

Table 4-13 NMVOCs, CO and SO_2 emissions from ammonia production in 1990-2017

Year	Quantity of Ammonia Produced (t)	Emission Factor (Kg pollutant/t Ammonia produced)	NMVOC (Gg)	CO (Gg)	SO_2 (Gg)
1990	C	4.7, 7.9, 0.03	0.94	1.58	C
1991	C	4.7, 7.9, 0.03	0.88	1.48	C
1992	C	4.7, 7.9, 0.03	0.50	0.85	C
1993	C	4.7, 7.9, 0.03	0.47	0.79	C
1994	C	4.7, 7.9, 0.03	0.25	0.42	C
1995	C	4.7, 7.9, 0.03	0.30	0.50	C
1996	C	4.7, 7.9, 0.03	0.44	0.74	C
1997	C	4.7, 7.9, 0.03	NE	NE	C
1998	C	4.7, 7.9, 0.03	0.36	0.61	C
1999	C	4.7, 7.9, 0.03	0.60	1.00	C
2000	C	4.7, 7.9, 0.03	0.64	1.08	C
2001	C	4.7, 7.9, 0.03	0.27	0.46	C
2002	C	4.7, 7.9, 0.03	0.52	0.88	C
2003	C	4.7, 7.9, 0.03	0.58	0.98	C
2004	C	4.7, 7.9, 0.03	0.62	1.04	C
2005	C	4.7, 7.9, 0.03	0.72	1.20	C
2006	C	4.7, 7.9, 0.03	0.81	1.36	C
2007	C	4.7, 7.9, 0.03	0.83	1.40	C
2008	C	4.7, 7.9, 0.03	0.87	1.46	C
2009	C	4.7, 7.9, 0.03	0.81	1.36	C
2010	C	4.7, 7.9, 0.03	0.94	1.58	C
2011	C	4.7, 7.9, 0.03	1.03	1.74	C
2012	C	4.7, 7.9, 0.03	1.04	1.75	C
2013	C	4.7, 7.9, 0.03	1.04	1.74	C
2014	C	4.7, 7.9, 0.03	1.04	1.74	C
2015	C	4.7, 7.9, 0.03	1.10	1.85	C
2016	C	4.7, 7.9, 0.03	0.86	1.45	C
2017	C	4.7, 7.9, 0.03	0.99	1.66	C

b) *Methodological Issues*

- ***Estimation Method***

The Tier 2 approach of the IPCC 2006 guideline was used for the calculation of the emissions from the Ammonia Production source-category. The approach is based on the factory specific data from ammonia production process.

- ***Emission factors***

The carbon content factor recommended by the IPCC 2006 is 15.3 kg of carbon per Gj of used natural gas. The carbon oxidation factor of natural gas has been provided by the Plant for the years of 1996, 1998-2015. The default value[76] has been applied for other years as recommended by the IPCC 2006. Other gases, such as NOx, NMVOCs, CO and SO_2. Are also emitted into the atmosphere as a result of ammonia production. These emissions are calculated using default emission factors proposed in the IPCC 1996 methodology. Emission coefficients of trace admixtures applied are given in *Table 4-14*.

[76]2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3, Chapter 3: Chemical Industry Emissions, p.3.15, Table 3.1)

Table 4-14 Emission coefficients of trace admixtures emitted from ammonia production[77]
(kg of gas / tonne of ammonia)

Gases emitted	NMNMVOCs	CO	SO_2
EF	4.7	7.9	0.03

- ***Activity data***

Natural gas consumption data are obtained from Ammonia producing plant in Rustavi - "Azoti." The performance of ammonia production factory in 1990-2015 years period is given in *Table 4-15.*

Table 4-15 Ammonia production data

Natural Gas in Ammonia Production					
Year	**Activity Data (Million m^3)**	**Year**	**Activity Data (Million m^3)**	**Year**	**Activity Data (Million m^3)**
1990	C	2000	C	2010	C
1991	C	2001	C	2011	C
1992	C	2002	C	2012	C
1993	C	2003	C	2013	C
1994	C	2004	C	2014	C
1995	C	2005	C	2015	C
1996	C	2006	C	2016	C
1997	C	2007	C	2017	C
1998	C	2008	C		
1999	C	2009	C		

- ***Point to Note***

Fuel consumption in this category has been deducted from energy sector activity data (see Chapter 3).

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty of each fuel was estimated. For the uncertainty of emission factors, the upper limit and lower limit values of the 95% confidence interval for the carbon emission factors were applied. For the uncertainty of the activity data, the same values were applied as in fuel combustion. As a result, the uncertainty of emissions is the following: natural gas -1 - +1%.

- ***Time-series Consistency***

For activity data, the same sources were used throughout the time series. The factory has provided activity data since 1990. The factory level data was not available for the year of 1997. To provide time-series consistency the interpolation method has been applied for recovery of the data in 1997. Therefore, CO_2 emission from ammonia production has been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the 2006 IPCC Guidelines. General inventory QC focuses on checking of the parameters for activity data and emission factors and archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

[77] http://www.ipcc-nggip.iges.or.jp/public/gl/invs5b.html (page 2.14, Table 2.4)

Recalculations have not been applied for this submission.

f) Category-specific Planned Improvements

Georgia is going to advance these assumptions by addressing its national circumstances and to provide relevant information in its forthcoming submissions in accordance with the study of the source-category under the project: "Georgia's Integrated Transparency Framework for Implementation of Paris Agreement".

4.3.2. Nitric Acid Production (2.B.2.)

a) Source-category description and calculated emissions

N_2O is emitted when nitric acid (HNO_3) is produced from ammonia.

Nitric acid (HNO_3) is produced as a result of catalytic oxidation of ammonia with an oxygen of air at high temperature. During this process nitrous oxide (N_2O) and nitrogen oxides (NOx-s) are produced as indirect products. The indirect gases absorbed by the vapor condensate[78]. The quantity of emitted gases is proportional to the quantity of consumed ammonia. Their concentration in exhaust gases depends on a type of plant's technology and a level of emissions control.

In 2014 the emissions were about C Gg CO_2 - one of the high values for the recent five years. The highest emission from the Nitric Acid Production in Georgia during the whole time series from 1990 to 2017 was estimated for the year of 2015 - 5%[79] higher than in the previous year (C Gg CO_2). In 2016 the emissions declined by 22% followed by 13% increase in 2017. The emissions estimated for the year of 1990 (C Gg CO_2) were about 43% lower compared to 2015. During three years after 1991 the emissions trend was descending, and it reached the level of 45 Gg CO_2 (depletion by 70%). During the two decades since the restitution of independence of Georgia the emissions dropped by 2.5 times compared to the 2000 level mainly due to the economic instability in the country. In 2010 the increase of the emissions from the Nitric Acid production was about 14% compared to the 2009 level. After this significant effect of emissions enlargement related to improvement of the factory performance the emissions upward trend steadily continued to grow and in 2015 the emissions level was 14% higher compared to the level of 2010.

Considering the available statistical data and above assumptions the calculated of nitrogen oxide emissions are given in *Table 4-16.*

Table 4-16 Nitrogen oxides emissions from nitric acid production in 1990-2017

Year	Quantity of Nitric Acid Produced (t)	Emission Factor (kg N_2O/t Nitric Acid produced)	N_2O Emitted (Gg)	CO_2 eq. Emitted (Gg)	Emission Factor (kg N_2O/t Nitric Acid produced)	NOx (Gg)
1990	C	2	C	C	12	C
1991	C	2	C	C	12	C
1992	C	2	C	C	12	C
1993	C	2	C	C	12	C
1994	C	2	C	C	12	C
1995	C	2	C	C	12	C
1996	C	2	C	C	12	C

[78]Factory technology description paper.

[79]The value was calculated based on the data expressed in thousands

Year	Quantity of Nitric Acid Produced (t)	Emission Factor (kg N_2O/t Nitric Acid produced)	N_2O Emitted (Gg)	CO_2 eq. Emitted (Gg)	Emission Factor (kg N_2O/t Nitric Acid produced)	NO_X (Gg)
1997	C	2	C	C	12	C
1998	C	2	C	C	12	C
1999	C	2	C	C	12	C
2000	C	2	C	C	12	C
2001	C	2	C	C	12	C
2002	C	2	C	C	12	C
2003	C	2	C	C	12	C
2004	C	2	C	C	12	C
2005	C	2	C	C	12	C
2006	C	2	C	C	12	C
2007	C	2	C	C	12	C
2008	C	2	C	C	12	C
2009	C	2	C	C	12	C
2010	C	2	C	C	12	C
2011	C	2	C	C	12	C
2012	C	2	C	C	12	C
2013	C	2	C	C	12	C
2014	C	2	C	C	12	C
2015	C	2	C	C	12	C
2016	C	2	C	C	12	C
2017	C	2	C	C	12	C

2B2 – Nitric Acid Production is a key source-category with regard to CO_2 eq. emissions. see Table 1-2

b) *Methodological Issues*

- ***Estimation Method***

The tier 1 methodology is used for calculation of emissions from the source-category of nitric acid production, since the activity data cover the amount of nitric acid produced per annum, in accordance with the IPCC 2006 Guideline.

- ***Emission factors***

According to the IPCC 2006[80] for factories with Non-Selective Catalytic Reduction (NSCR) technology the emission coefficient for nitrous oxide (N_2O) is equal to 2 kg of N_2O / tonne of HNO_3. The estimation presented in First BUR considered emission factor of 6.75 kg of N_2O / tonne of HNO_3 calculated as an average of medium pressure production default emission factors. The change of emission factor is caused by the technology line description provided by the factory. The Rustavi synthetic fertilizer's plant uses the NSCR technology for abatement of the nitrogen oxides (NO_x). The N_2O is further removed in this catalyst bed.

- ***Activity data***

The source of Nitric acid production data is nitric acid production - Rustavi synthetic fertilizer's plant. The so-called weak nitric acid is produced by catalytic oxidation of ammonia with oxygen from the air, followed by the absorption of oxides generated with water vapor at medium pressure.

[80] http://www.ipcc-nggip.iges.or.jp/public/gl/invs5b.html (page 2.16, Table 2.5 and 2.6)

Table 4-17. Nitric acid production data

Nitric Acid Production					
Year	Activity Data (t)	Year	Activity Data (t)	Year	Activity Data (t)
1990	C	2000	C	2010	C
1991	C	2001	C	2011	C
1992	C	2002	C	2012	C
1993	C	2003	C	2013	C
1994	C	2004	C	2014	C
1995	C	2005	C	2015	C
1996	C	2006	C	2016	C
1997	C	2007	C	2017	C
1998	C	2008	C		
1999	C	2009	C		

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

As for the uncertainty of the emission factor, the standard deviation was calculated from the emission factors and production amounts and was assessed to be 73%. For the uncertainty of activity data, the default value of 2%, provided by the 2006 IPCC Guidelines was applied. As a result, the uncertainty of emissions was estimated as 73%.

- ***Time-series Consistency***

For activity data, the same sources are used throughout the time series. The factory has provided activity data since 1990. The factory level data was not available for the year of 1997. to provide time-series consistency the interpolation method has been applied for recovery of the data in 1997. Therefore, CO_2 emission from nitric acid production has been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the 2006 IPCC Guidelines. General inventory QC focuses on checking of the parameters for activity data and emission factors and archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculations have not been applied for this submission.

f) Category-specific Planned Improvements

Georgia is going to advance these assumptions by addressing its national circumstances and to provide relevant information in its forthcoming submissions in accordance with the study of the source-category under the project: "Georgia's Integrated Transparency Framework for Implementation of Paris Agreement".

4.3.3. Adipic Acid Production (2.B.3.)

This source category does not exist in Georgia.

4.3.4. Caprolactam, glyoxal and glyoxylic acid production (2.B.4.)

This source category does not exist in Georgia.

4.3.4.1. Caprolactam Production (2.B.4.a)

This source category does not exist in Georgia.

4.3.4.2. Caprolactam Production (2.B.4.a)

This source category does not exist in Georgia.

4.3.4.3. Glyoxylic acid Production (2.B.4.c)

This source category does not exist in Georgia.

4.3.5. Carbide Production (2.B.5.)

This source category does not exist in Georgia.

4.3.5.1. Silicon Carbide Production (2.B.5.a)

This source category does not exist in Georgia.

4.3.5.2. Calcium Carbide Production and Use (2.B.5.b)

This source category does not exist in Georgia.

4.3.6. Calcium Carbide Production and Use (2.B.5.b)

This source category does not exist in Georgia.

4.3.7. Soda Ash Production (2.B.7.)

This source category does not exist in Georgia.

4.3.8. Petrochemical and Carbon Black Production (2.B.8.)

This source category does not exist in Georgia.

4.3.8.1. Methanol Production (2.B.8.a)

This source category does not exist in Georgia.

4.3.8.2. Ethylene Production (2.B.8.b)

This source category does not exist in Georgia.

4.3.8.3. 1,2-Dichloroethane and Chloroethylene (2.B.8.c)

This source category does not exist in Georgia.

4.3.8.4. Ethylene oxide Production (2.B.8.d)

This source category does not exist in Georgia.

4.3.8.5. Acrylonitrile Production (2.B.8.e)

This source category does not exist in Georgia.

4.3.8.6. Carbon Black Production (2.B.8.f)

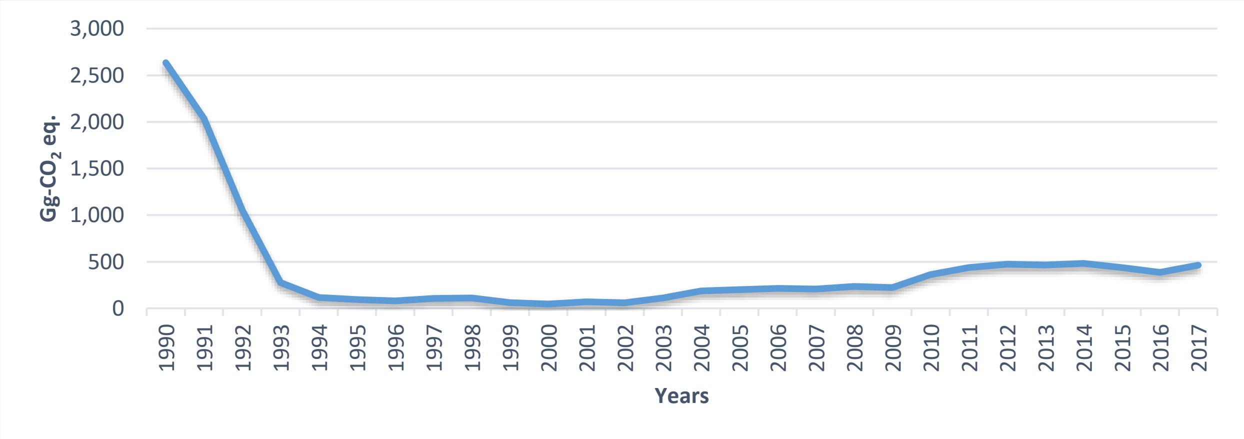
This source category does not exist in Georgia.

4.4. Metal Industry (2.C.)

The sub-sector of the metal production covers steel (2.C.1) and ferroalloys (2.C.2) processing in Georgia. In 2017 the GHG emissions from the sub-sector of the metal production was 23% of total emissions from the Industrial Processes and Product use.

The emissions from the ferroalloys production are about 26 times higher than the emissions from the steel production. The significant difference in produced emissions between the source-categories mostly relates to the technology used in steel production. In Georgia, the steel manufacturing uses Electric Arc Furnace characterized as low emitter. By contrast, the steel production was the biggest contributor in GHG emissions in 90's. Accordingly, since 2000 the emission trend for the Metal Production sub-sector was mostly maintained by the ferroalloys production source-category, while the steel production was the leader in the past. The trend is illustrated in the *Figure 4-3* beneath.

Figure 4-3 The emission trend from the metal production



The highest emissions from the sub-sector of metal production was estimated in 1990 and was about 2635 Gg- CO_2 eq.; it was mainly caused by performance improvement in both production lines. The emissions value at the end of the estimation period was 83% lower compare to the value estimated in 1990. The emissions from the sub-sector significantly declined for four years following 1990. Although the production processes of both types of metal industry have been reduced, the steep depletion of the GHG emission mainly relates to the termination of the sinter and cast-iron productions. The transformation period was characterized with a crisis in economic development translated into the lowest level of GHG emissions from the sub-sector for the period between 1996 and 2003. The collapse of socialist system has caused the reduction of production of steel goods more than nineteen times. In 1996 the emissions dropped by 97% compared to the 1990 level. In 2000 the emissions reached its lowest level for the whole time series period - 46 Gg-CO_2 eq. (only 1.7% of 1990 level). The emissions increased between 2002 and 2006 by approximately 72%. The largest upturn was recorded in 2009-2012 - from 224 Gg to 473 Gg-CO_2 eq. At the end of the period the emissions slightly declined (by 9%) compared to the value calculated for the year of 2014. In 2016 the emissions declined by 12% compared to the previous year followed by 17% increase in 2017.The emissions trend is illustrated in the *Figure 4-3* above.

4.4.1. Iron and Steel Production (2.C.1.)

Currently, the Steel production is carried out by two major factories - LTD Georgia Rustavi Steel and Geosteel using Electric Arc Furnace. In the recent past the steel was produced by the only metallurgical factory in Georgia - LTD Georgia Rustavi Steel. In 1990 the several technological lines were operated in the factory, particularly it had a sinter production, pig iron production and steel production via marten kiln lines. In 1993 the pig iron production was terminated. The sinter production was closed in the following year. The use of marten kilns was terminated in 1999. During 2000 - 2010 years period the factory produced steel by melting the cast iron, which is not characterized by the industrial GHG emissions.

Since 2010 the steel production through the EAF was launched by Geosteel and two years later the Rustavi Steel joined it. During the recent few years, the trend was characterized by the significantly low emissions compared to the emissions related to the years of 1990-1992.

In 2017 the emissions were about C Gg CO_2 - the highest value for the recent eight years. It has increased by 90 per cent[81] compared to the value of the year of 2010. The emission had an upward trend between 2010- and 2017-years period. The highest emissions from the Cast Iron and Steel production in Georgia were estimated in 1990 - C Gg of CO_2 during the whole time series from 1990 to 2017. Following nine years the emissions trend was descending and it reached the level of 0 Gg CO_2 in 2000. The emission in 2017 was C times lower than it used to be in 1990.

4.4.1.1. Steel Production (2.C.1.a)

4.4.1.2. Use of Electric Arc Furnaces in Steel Production (2.C.1.a)

a) Source-category description and calculated emissions

"In a majority of scrap charged EAF, CO_2 emissions are mainly associated with consumption of the carbon electrodes. All carbon used in EAFs and other steelmaking processes should be considered process related IPPU emissions"[82].

In 2017 the emissions were about C Gg CO_2 - the highest value for the recent eight years. It increased by 90%[83] compared to the value of the year 2010. The emission had an upward trend between 2010- and 2017-years period. The highest emissions from the Cast Iron and Steel production in Georgia were estimated in 1990 - C Gg of CO_2 during the whole time series from 1990 to 2017. Following nine years the emissions trend was descending and it reached the level of 0 Gg CO_2 in 2000. The emission in 2017 was C times lower than it used to be in 1990.

The emissions calculated, based on statistical data provided in this subsector and on the emission coefficients provided in the methodological instructions of the IPCC 2006 Guidelines, are presented in the Table *4-21*, Table *4-22*, Table *4-23*, Table *4-24*.

[81] The value was calculated based on the data expressed in thousands
[82] 2006 IPCC Guidelines Volume 3, Chapter 4 Metal Industry, p. 4.12
[83] The value was calculated based on the data expressed in thousands

Table 4-18 CO_2 emissions from the steel production by EAF in 1990 - 2017

Year	Amount of Steel Produced (Gg)	Amount of Coke input (Gg)	Amount of natural gas input (Pj)	Amount of limestone input (Gg)	Amount of Heavy oil input (Gg)	Amount of Graphite input (Gg)	Amount of Ferrosilicon input (Gg)	Amount of Silicomanganum input (Gg)	Amount of Sinter input (Gg)	Amount of Pig Iron input (Gg)	Amount of Rust input (Gg)	CO_2 Emitted (Gg)
1990	C	338.4	3,537.4	139.4	155.6	1.95	3.89	12.96	1,134.4	NO	648.2	C
1991	C	249.9	2,613.0	103.0	144.9	1.44	2.87	9.58	837.9	NO	478.8	C
1992	C	137.4	1,449.2	56.6	63.2	0.79	1.58	5.27	460.7	NO	26.3	C
1993	C	0.2	121.2	21.7	26.0	0.33	0.65	2.17	NO	108.4	108.4	C
1994	C	0.1	67.2	12.0	2.4	0.18	0.36	1.19	NO	59.9	59.9	C
1995	C	0.1	49.3	8.7	10.5	0.13	0.26	0.87	NO	43.7	43.7	C
1996	C	0.1	46.8	8.2	9.9	0.12	0.25	0.83	NO	41.3	41.3	C
1997	C	0.1	59.3	10.4	12.5	0.16	0.31	0.10	NO	52.1	52.1	C
1998	C	0.01	32.2	5.6	6.8	0.09	0.17	0.56	NO	28.2	28.2	C
1999	C	0.084	4.0	0.7	0.8	0.01	0.02	0.07	NO	3.5	3.5	C
2000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2001	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2002	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2003	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2004	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2005	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2006	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2007	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2008	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2009	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2010	C	0.62	NO	0.2	0.10	NO	0.36	106.24	2.12	NO	NO	NO
2011	C	2.99	NO	0.5	0.57	NO	0.70	134.47	1.04	NO	NO	NO

[84] 0.007

Year	Amount of Steel Produced (Gg)	Amount of Coke input (Gg)	Amount of natural gas input (Pj)	Amount of limestone input (Gg)	Amount of Heavy oil input (Gg)	Amount of Graphite input (Gg)	Amount of Ferrosilicon input (Gg)	Amount of Silicomanganum input (Gg)	Amount of Sinter input (Gg)	Amount of Pig Iron input (Gg)	Amount of Rust input (Gg)	CO_2 Emitted (Gg)
2012	C	3.63	NO	0.8	2.13	0.03	0.78	159.88	1.45	2.0	3.0	C
2013	C	4.57	NO	1.1	0.92	0.13	1.22	177.85	2.60	5.6	15.9	C
2014	C	6.11	NO	1.4	1.00	0.20	1.48	204.73	2.40	8.0	24.1	C
2015	C	7.38	NO	1.6	1.56	0.26	1.77	228.78	2.65	10.3	31.8	C
2016	C	8.61	NO	1.9	1.37	0.28	2.01	252.59	2.77	10.9	33.8	C
2017	C	9.82	NO	2.2	1.50	0.28	2.23	276.46	2.85	9.5	33.8	C

b) Methodological Issues

- ***Estimation Method***

The Tier 2 approach of the IPCC 2006 Guideline is applied; the approach calculates the emissions by multiplication of the quantity of process inputs and outputs for steel making via EAF.

$$E_{CO2} = [PC \times C_{PC} + NG \times C_{NG} + L \times C_L + HO \times C_{HO} + G \times C_G + F \times C_F + SM \times C_{SM} + S \times C_S + PI \times C_{PI} + R \times C_R - St \times C_{St}] \times \frac{44}{12}$$

Where:

E_{CO2} = Emissions from the steel production via EAF
PC = Quantity of coke used for steel production
C_{PC} = Carbon content in the consumed coke
NG = Quantity of natural gas used for steel production
C_{NG} = Carbon content in the consumed natural gas
L = Quantity of limestone used for steel production
C_L = Carbon content in the consumed limestone
HO = Quantity of heavy oil used for steel production
C_{HO} = Carbon content in the consumed heavy oil
G = Quantity of graphite used for steel production
C_G = Carbon content in the consumed graphite
F = Quantity of ferrosilicon used for steel production
C_F = Carbon content in the consumed ferrosilicon
SM = Quantity of silicomanganese used for steel production
C_{SM} = Carbon content in the consumed silicomanganese
S = Quantity of sinter used for steel production
C_S = Carbon content in the consumed sinter
PI = Quantity of pig iron used for steel production
C_{PI} = Carbon content in the consumed pig iron
R = Quantity of rust used for steel production
C_R = Carbon content in the consumed rust
St = Quantity of steel produced through the EAF
C_{St} = Carbon content in the produced steel

- ***Emission factors***

The process inputs and outputs carbon content data for the steel production have been obtained from the factories.

- ***Activity Data***

The factories: LTD Georgia Rustavi Steel and Geosteel are the sources for the steel production data (*Table 4-19*).

Table 4-19. Steel production data

Steel Production					
Year	**Activity Data (t)**	**Year**	**Activity Data (t)**	**Year**	**Activity Data (t)**
1990	C	2000	C	2010	C
1991	C	2001	C	2011	C
1992	C	2002	C	2012	C
1993	C	2003	C	2013	C
1994	C	2004	C	2014	C
1995	C	2005	C	2015	C
1996	C	2006	C	2016	C
1997	C	2007	C	2017	C
1998	C	2008	C		
1999	C	2009	C		

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The factory specific values were applied for the uncertainty of the CO_2 emission factor and activity data for steel production. As a result, the uncertainty of emissions was estimated to be 4%.

- ***Time-series Consistency***

Emissions throughout the time series are consistently estimated using the activity data provided by the factories.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the 2006 IPCC Guidelines. General inventory QC focuses on checking of the parameters for activity data and emission factors and archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculations have not been applied for this submission.

f) Category-specific Planned Improvements

Georgia is going to advance these assumptions by addressing its national circumstances and to provide relevant information in its forthcoming submissions in accordance with the study of the source-category under the project: “Georgia’s Integrated Transparency Framework for Implementation of Paris Agreement”.

4.4.1.3. Pig Iron Production (2.C.1.b)

This source category does not exist in Georgia.

4.4.1.4. Direct reduced iron production (2.C.1.c)

This source category does not exist in Georgia.

4.4.1.5. Sinter Production (2.C.1.d)

In 1990 the emissions were about C Gg CO_2 the highest value for the four years period. The emissions declined steadily and in 1995 the sinter production was terminated in Georgia.

This source category does not exist in Georgia.

Table 4-20 CO_2 emissions from the sinter production in 1990 - 2017

Year	Amount of Sinter Produced (t)	EF (CH_4 kg/t Sinter)	CH_4 Emissions (t)	CH_4 Emissions (Gg)	CO_2 eq. Emissions (Gg)
1990	C	0.07	C	C	C
1991	C	0.07	C	C	C
1992	C	0.07	C	C	C
1993	C	0.07	C	C	C
1994	C	0.07	C	C	C
1995	NA	NA	NA	NA	NA
1996	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA
1998	NA	NA	NA	NA	NA
1999	NA	NA	NA	NA	NA
2000	NA	NA	NA	NA	NA
2001	NA	NA	NA	NA	NA
2002	NA	NA	NA	NA	NA
2003	NA	NA	NA	NA	NA
2004	NA	NA	NA	NA	NA
2005	NA	NA	NA	NA	NA
2006	NA	NA	NA	NA	NA
2007	NA	NA	NA	NA	NA
2008	NA	NA	NA	NA	NA
2009	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA
2012	NA	NA	NA	NA	NA
2013	NA	NA	NA	NA	NA
2014	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA
2016	NA	NA	NA	NA	NA
2017	NA	NA	NA	NA	NA

4.4.1.6. Pellet Production (2.C.1.e)

This source category does not exist in Georgia.

4.4.2. Ferroalloys Production (2.C.2.)

a) Source-category description and calculated emissions

The ferroalloy plants produce the enriched alloys that are transmitted to the steel producing plants for manufacturing steel alloy. Ferroalloys production includes the metallurgical reduction process that causes significant emission of CO_2 and minor emission of CH_4. The ferroalloys including Ferro silicomanganese, Ferrosilicon, and Ferromanganese are produced by several plants in Georgia. The dominant product is silicomanganese - with about 82% share, followed by ferrosilicon - with 14% share and ferromanganese - with 4 per cent share.

In 2015 the emissions were about 405 Gg CO_2 eq. - the lowest value for the recent five years. It slightly declined (by 11 per cent)[85] compared to the value of 2014. In 2016 the emissions declined by 14 % followed by 18 % increase in 2017. The emission had a fluctuating trend between 2011 and 2017 period. The highest emissions from the ferroalloys production in Georgia during the whole time series from 1990 to 2017 were estimated in 2012 - 457 Gg of CO_2 eq. At the beginning of the period the emission was 74 % lower than in 2017. During the following six years the emissions trend was descending and it reached the level of 25 Gg CO_2 eq. in 1996, the minimum level of emissions for the whole estimating period.

The emissions calculated based on statistical data provided in this subsector and on the emission coefficients provided in the methodological instructions of the IPCC 2006 Guidelines, are presented in the Table *4-21*, Table *4-22*, Table *4-23*, Table *4-24*.

Table 4-21 CO_2 emissions (Gg) from production of the Ferro silicomanganese in 1990-2017

Year	Amount of Ferrosilicomanganese Produced (t)	Emission Factor (t CO_2/t Ferroalloy Produced)	CO_2 Emitted (t)	CO_2 Emitted (Gg)	Year	Amount of Ferrosilicomanganese Produced (t)	Emission Factor (t CO_2/t Ferroalloy Produced)	CO_2 Emitted (t)	CO_2 Emitted (Gg)
1990	67,363	1.4	94,308	94.31	2004	88,062	1.4	123,286	123.29
1991	45,595	1.4	63,833	63.83	2005	94,430	1.4	132,201	132.20
1992	20,529	1.4	28,741	28.74	2006	100,797	1.4	141,116	141.12
1993	22,420	1.4	31,388	31.39	2007	97,589	1.4	136,625	136.63
1994	13,835	1.4	19,368	19.37	2008	110,892	1.4	155,249	155.25
1995	16,640	1.4	23,295	23.30	2009	105,480	1.4	147,672	147.67
1996	12,061	1.4	16,885	16.89	2010	168,270	1.4	235,578	235.58
1997	17,015	1.4	23,821	23.82	2011	200,435	1.4	280,610	280.61
1998	34,751	1.4	48,652	48.65	2012	215,569	1.4	301,797	301.80
1999	26,992	1.4	37,789	37.79	2013	209,200	1.4	292,880	292.88
2000	21,919	1.4	30,687	30.69	2014	214,141	1.4	299,798	299.80
2001	33,523	1.4	46,932	46.93	2015	190,757	1.4	267,060	267.06
2002	28,605	1.4	40,047	40.05	2016	239,701	1.4	335,581	335.58
2003	52,314	1.4	73,239	73.24	2017	289,142	1.4	404,799	404.80

Table 4-22 CO_2 emissions (Gg) from production of the Ferromanganese in 1990-2017

Year	Amount of Ferromanganeses Produced (t)	Emission Factor (t CO_2/t Ferroalloy Produced)	CO_2 Emitted (t)	CO_2 Emitted (Gg)	Year	Amount of Ferromanganeses Produced (t)	Emission Factor (t CO_2/t Ferroalloy Produced)	CO_2 Emitted (t)	CO_2 Emitted (Gg)
1990	3,165	1.3	4,115	4.12	2004	4,138	1.3	5,379	5.38
1991	2,143	1.3	2,785	2.79	2005	4,437	1.3	5,768	5.77
1992	965	1.3	1,254	1.25	2006	4,737	1.3	6,157	6.16
1993	1,054	1.3	1,370	1.37	2007	4,586	1.3	5,962	5.96
1994	650	1.3	845	0.85	2008	5,211	1.3	6,774	6.77
1995	782	1.3	1,016	1.02	2009	4,957	1.3	6,444	6.44
1996	567	1.3	737	0.74	2010	7,907	1.3	10,279	10.28
1997	800	1.3	1,039	1.04	2011	9,419	1.3	12,244	12.24
1998	1,633	1.3	2,123	2.12	2012	10,130	1.3	13,169	13.17
1999	1,268	1.3	1,649	1.65	2013	9,830	1.3	12,780	12.78
2000	1,030	1.3	1,339	1.34	2014	10,063	1.3	13,081	13.08
2001	1,575	1.3	2,048	2.05	2015	8,964	1.3	11,653	11.65
2002	1,344	1.3	1,747	1.75	2016	2,446	1.3	3,180	3.18

[85] The value was calculated based on the data expressed in thousands

Year	Amount of Ferromanganeses Produced (t)	Emission Factor (t CO_2/t Ferroalloy Produced)	CO_2 Emitted (t)	CO_2 Emitted (Gg)	Year	Amount of Ferromanganeses Produced (t)	Emission Factor (t CO_2/t Ferroalloy Produced)	CO_2 Emitted (t)	CO_2 Emitted (Gg)
2003	2,458	1.3	3,196	3.20	2017	2,950	1.3	3,836	3.84

Table 4-23 CO_2 emissions (Gg) from production of the Ferrosilicon in 1990-2017

Year	Amount of Ferrosilicon Produced (t)	Emission Factor (t CO_2/t Ferroalloy Produced)	CO_2 Emitted (t)	CO_2 Emitted (Gg)	Year	Amount of Ferrosilicon Produced (t)	Emission Factor (t CO_2/t Ferroalloy Produced)	CO_2 Emitted (t)	CO_2 Emitted (Gg)
1990	11,054	4	44,218	44.22	2004	14,451	4	57,805	57.80
1991	7,482	4	29,929	29.93	2005	15,496	4	61,985	61.98
1992	3,369	4	13,476	13.48	2006	16,541	4	66,165	66.16
1993	3,679	4	14,717	14.72	2007	16,015	4	64,059	64.06
1994	2,270	4	9,081	9.08	2008	18,198	4	72,791	72.79
1995	2,731	4	10,922	10.92	2009	17,310	4	69,238	69.24
1996	1,979	4	7,917	7.92	2010	27,614	4	110,455	110.45
1997	2,792	4	11,169	11.17	2011	32,892	4	131,568	131.57
1998	5,703	4	22,811	22.81	2012	35,376	4	141,502	141.50
1999	4,429	4	17,718	17.72	2013	34,330	4	137,322	137.32
2000	3,597	4	14,388	14.39	2014	35,141	4	140,565	140.57
2001	5,501	4	22,005	22.00	2015	31,304	4	125,216	125.22
2002	4,694	4	18,777	18.78	2016	2,446	4	9,784	9.78
2003	8,585	4	34,339	34.34	2017	2,950	4	11,802	11.80

Table 4-24 CH_4 emissions (Gg) from production of the Ferrosilicon in 1990-2017

Year	Amount of Ferrosilicon Produced (t)	Emission Factor (t CH_4/t Ferroalloy Produced)	CH_4 Emitted (t)	CH_4 Emitted (Gg)	CO_2 eq. Emitted (Gg)	Year	Amount of Ferrosilicon Produced (t)	Emission Factor (t CH_4/t Ferroalloy Produced)	CH_4 Emitted (t)	CH_4 Emitted (Gg)	CO_2 eq. Emitted (Gg)
1990	11,054	0.001	11.05	0.011	0.23	2004	14,451	0.001	14.45	0.014	0.30
1991	7,482	0.001	7.48	0.007	0.16	2005	15,496	0.001	15.50	0.015	0.33
1992	3,369	0.001	3.37	0.003	0.07	2006	16,541	0.001	16.54	0.017	0.35
1993	3,679	0.001	3.68	0.004	0.08	2007	16,015	0.001	16.01	0.016	0.34
1994	2,270	0.001	2.27	0.002	0.05	2008	18,198	0.001	18.20	0.018	0.38
1995	2,731	0.001	2.73	0.003	0.06	2009	17,310	0.001	17.31	0.017	0.36
1996	1,979	0.001	1.98	0.002	0.04	2010	27,614	0.001	27.61	0.028	0.58
1997	2,792	0.001	2.79	0.003	0.06	2011	32,892	0.001	32.89	0.033	0.69
1998	5,703	0.001	5.70	0.006	0.12	2012	35,376	0.001	35.38	0.035	0.74
1999	4,429	0.001	4.43	0.004	0.09	2013	34,330	0.001	34.33	0.034	0.72
2000	3,597	0.001	3.60	0.004	0.08	2014	35,141	0.001	35.14	0.035	0.74
2001	5,501	0.001	5.50	0.006	0.12	2015	31,304	0.001	31.30	0.031	0.66
2002	4,694	0.001	4.69	0.005	0.10	2016	2,446	0.001	2.45	0.002	0.05
2003	8,585	0.001	8.58	0.009	0.18	2017	2,950	0.001	2.95	0.003	0.06

2C2 – Ferroalloys Production is a key source-category regarding CO_2 emissions. see Table 1-2

b) Methodological Issues

- ***Estimation Method***

The Tier I approach of the IPCC 2006 Guideline is applied. The approach calculates the emissions by multiplication of the quantity of produced ferroalloys and typical emission factors for each type of ferroalloys.

$$E_{CO2} = F \times EF$$

Where:

E_{CO2} – CO_2 emissions from Ferroalloys production
F – Amount of Ferroalloys produced
EF – Emission Factor related to the ferroalloys production

- ***Emission factors***

The default EFs for the ferrosilicon, ferromanganese, and silicomanganese have been taken from the 2006 Guidelines. Accordingly, 4 tonnes of CO_2/tonne of produced ferrosilicon, 1.3 tonne of CO_2/tonne of produced ferromanganese, 1.4 tonne of CO_2/tonne of produced silicomanganese.

- ***Activity Data***

The State National Statistics Office is the source for the ferroalloy production data. Only silicon manganese, ferromanganese and ferrosilicon were produced; 30-40 kg of carbon electrodes was consumed, 2.5 tonnes of 25-40% rich iron ore was processed, 450-500 kg of reducer was consumed for production of 1 tonne of the silicon manganese (Table 4-25, Table 4-26, Table 4-27).

Table 4-25. Ferro silicomanganese production data

Ferro silicomanganese Production					
Year	**Activity Data (t)**	**Year**	**Activity Data (t)**	**Year**	**Activity Data (t)**
1990	67,363	2000	21,919	2010	168,270
1991	45,595	2001	33,523	2011	200,435
1992	20,529	2002	28,605	2012	215,569
1993	22,420	2003	52,314	2013	209,200
1994	13,835	2004	88,062	2014	214,141
1995	16,640	2005	94,430	2015	190,757
1996	12,061	2006	100,797	2016	239,701
1997	17,015	2007	97,589	2017	289,142
1998	34,751	2008	110,892		
1999	26,992	2009	105,480		

Table 4-26. Ferromanganese production data

Ferromanganese Production					
Year	**Activity Data (t)**	**Year**	**Activity Data (t)**	**Year**	**Activity Data (t)**
1990	3,165	2000	1,030	2010	7,907
1991	2,143	2001	1,575	2011	9,419
1992	965	2002	1,344	2012	10,130
1993	1,054	2003	2,458	2013	9,830
1994	650	2004	4,138	2014	10,063
1995	782	2005	4,437	2015	8,964
1996	567	2006	4,737	2016	2,446
1997	800	2007	4,586	2017	2,950
1998	1,633	2008	5,211		
1999	1,268	2009	4,957		

Table 4-27. Ferrosilicon production data

Ferrosilicon Production					
Year	**Activity Data (t)**	**Year**	**Activity Data (t)**	**Year**	**Activity Data (t)**
1990	11,054	2000	3,597	2010	27,614
1991	7,482	2001	5,501	2011	32,892
1992	3,369	2002	4,694	2012	35,376
1993	3,679	2003	8,585	2013	34,330
1994	2,270	2004	14,451	2014	35,141
1995	2,731	2005	15,496	2015	31,304
1996	1,979	2006	16,541	2016	2,446
1997	2,792	2007	16,015	2017	2,950
1998	5,703	2008	18,198		
1999	4,429	2009	17,310		

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The default value provided in the *2006 IPCC Guidelines* was applied for the uncertainty of the CO_2 emission factor and activity data for cement production. . As a result, the uncertainty of emissions was estimated to be 4%.

- ***Time-series Consistency***

Emissions throughout the time series are consistently estimated using the activity data provided by the Statistics Office of Georgia.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the2006 IPCC Guidelines. General inventory QC focuses on checking of the parameters for activity data and emission factors and archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculations have not been applied for this submission.

f) Category-specific Planned Improvements

Georgia is going to advance these assumptions by addressing its national circumstances and to provide relevant information in its forthcoming submissions in accordance with the study of the source-category under the project: "Georgia's Integrated Transparency Framework for Implementation of Paris Agreement".

4.4.3. Aluminum Production (2.C.3.)

This source category does not exist in Georgia.

4.4.4. Magnesium Production (2.C.4.)

This source category does not exist in Georgia.

4.4.5. Lead production (2.C.5.)

This source category does not exist in Georgia.

4.4.6. Zinc production (2.C.6.)

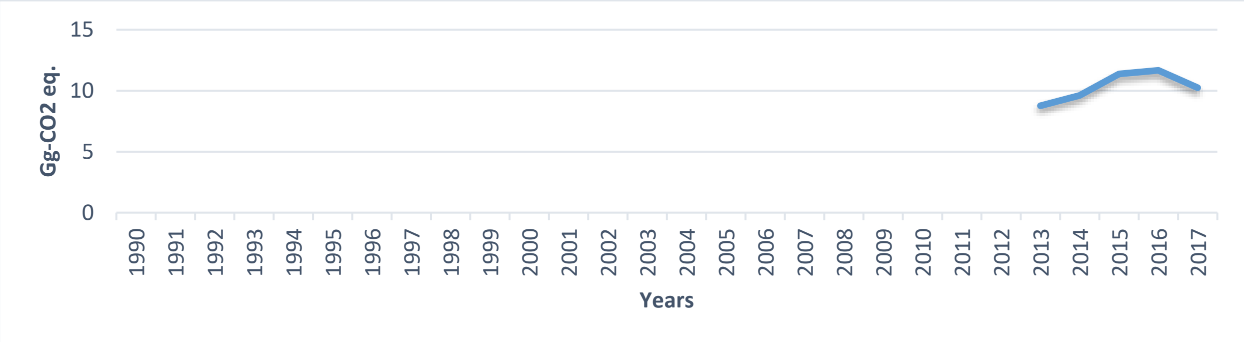
This source category does not exist in Georgia.

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

The Sub-sector of the Non-energy products from fuels and solvent use in Georgia considers emissions from the Lubricants (2.D.1) and Paraffin Wax use (2.D.2) source-categories. In 2017 the GHG emissions from the sub-sector of the chemical industry was 0.5% of total emissions from the Industrial Processes and Product use.

The activity data on the usage of Lubricants and wax for non-energy purposes has been collected since the national statistics office launched the energy balance processing. Accordingly, the emissions have been estimated for the period of years of 2013 – 2017. In 2016 the emissions were 10.25 Gg-CO_2 eq. - the highest level during the estimation period followed by 12% decrease in 2017. The biggest contributor to the upward trend within this period was the amount of consumed lubricants. The emissions trend is illustrated in the *Figure 4-4* beneath.

Figure 4-4 The emissions trend from the Non-energy products from fuels and solvent use



4.5.1. Lubricant use (2.D.1.)

a) Source-category description and calculated emissions

In 2015 the emissions were about 11.07 Gg CO_2 eq. - the highest value for the recent three years. It slightly increased (by 15%)[86] compared to the value of 2014. The emission had an upward trend between 2013 and 2015 years period. At the beginning of the period the emission was 24% lower than in 2015.

The emissions calculated based on statistical data provided in this subsector and on the emission coefficients provided in the methodological instructions of the IPCC 2006 Guidelines, are presented in the *Table 4-28*.

Table 4-28 CO_2 Emissions from lubricant use 2013-2017

Year	Total Lubricant consumed (TJ)	Carbon content factor of the lubricant (kg C/GJ)	ODU factor of the lubricant (fraction)	Mass ration of CO_2/C	CO_2 Emitted (Gg)
2013	570.7	20	0.2	44/12	8.37
2014	638.4	20	0.2	44/12	9.36
2015	754.8	20	0.2	44/12	11.07
2016	795.7	20	0.2	44/12	11.67

[86] The value was calculated based on the date expressed in thousandths

Year	Total Lubricant consumed (TJ)	Carbon content factor of the lubricant (kg C/GJ)	ODU factor of the lubricant (fraction)	Mass ration of CO_2/C	CO_2 Emitted (Gg)
2017	698.8	20	0.2	44/12	10.25

b) Methodological Issues

- ***Estimation Method***

The Tier I approach of the IPCC 2006 guideline is applied; the approach calculates the emissions by multiplication of the quantity of used lubricants and typical emission factor.

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

Where:

$CO_2\ Emissions$ = CO_2 emissions from lubricants, tonne CO_2
LC = total lubricant consumption, TJ
$CC_{Lubricant}$ = carbon content of lubricants (default), tonne C/TJ (= kg C/GJ)
$ODU_{Lubricant}$ = ODU factor (based on default composition of oil and grease), fraction
$44/12$ = mass ratio of CO_2/C

- ***Emission Factors***

The default carbon content factor (20 kg C/GJ) for lubricants and ODU factor (0.2) have been taken from the 2006 Guidelines[87].

- ***Activity Data***

The State National Statistics Office is the source for the Lubricant use data for the non-energy purposes.

Table 4-29. Lubricant consumption data

Lubricant consumed					
Year	Activity Data (TJ)	Year	Activity Data (TJ)	Year	Activity Data (TJ)
2013	570.7	2015	754.8	2017	698.8
2014	638.4	2016	795.7		

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of emission factors, a 50% default value provided in the 2006 IPCC Guidelines was applied for both lubricants and grease. For the uncertainty of the activity data, a 5% default value provided in the 2006 IPCC Guidelines was applied for both lubricants and grease. As a result, the uncertainty of emissions was assessed to be 50% for both lubricants and grease.

- ***Time-series Consistency***

[87] 2006 IPCC Guidelines for National Greenhouse Gas Inventories Vol.3 Chapter 5, Table 5.2 p.5.9

The Statics office of Georgia started producing energy balance in 2013. Emissions for the period of 2013 and 2017 are consistently estimated using the activity data provided by the Statistics Office of Georgia.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the2006 IPCC Guidelines. General inventory QC focuses on checking of the parameters for activity data and emission factors and archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculations have not been applied for this submission.

f) Category-specific Planned Improvementsto

Georgia is going to advance these assumptions by addressing its national circumstances and provide relevant information in its forthcoming submissions in accordance with the study of the source-category under the project: “Georgia’s Integrated Transparency Framework for Implementation of Paris Agreement”.

4.5.2. Paraffin wax use (2.D.2.)

a) Source-category description and calculated emissions

In 2015 the emissions were about 0.3 Gg CO_2 eq. - the average value for the recent three years. It slightly increased (by 17%)[88] compared to the value of 2014. The emission had an upward trend between 2014- and 2015-years period. At the beginning of the period the emission was 23% higher than in 2015.

The emissions calculated based on statistical data provided in this subsector and on the emission coefficients provided in the methodological instructions of the IPCC 2006 Guidelines, are presented in the Table *4-30*.

Table 4-30 CO_2 Emissions from paraffin wax use 2013-2017

Year	Total Paraffin Wax consumed (TJ)	Carbon content factor of the paraffin wax (kg C/GJ)	ODU factor of the paraffin wax (fraction)	Mass ration of CO_2/C	CO_2 Emitted (Gg)
2013	26.9	20	0.2	44/12	0.39
2014	17.1	20	0.2	44/12	0.25
2015	20.6	20	0.2	44/12	0.30
2016	NE	NE	NE	NE	NE
2017	NE	NE	NE	NE	NE

b) Methodological Issues

- ***Estimation Method***

The Tier I approach of the IPCC 2006 Guideline is applied; the approach calculates the emissions by multiplication of the quantity of used paraffin waxes and typical emission factors.

$$CO_2 Emissions = PW \times CC_{Wax} \times ODU_{Wax} \times 44/12$$

[88]The value was calculated based on the data expressed in thousands

Where:

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

PW = total wax consumption, TJ

CC_{Wax} = carbon content of paraffin wax (default), tonne C/TJ (= kg C/GJ)

ODU_{Wax} = ODU factor for paraffin wax, fraction

44/12 = mass ratio of CO_2/C

- ***Emission Factors***

The default carbon content factor (20 kg C/GJ) for lubricants and ODU factor (0.2) have been taken from the 2006 Guidelines[89].

- ***Activity Data***

The State National Statistics Office is the source for the wax use data for the non-energy purposes.

Table 4-31. Paraffin wax consumption data

Paraffin Wax consumed					
Year	**Activity Data (TJ)**	**Year**	**Activity Data (TJ)**	**Year**	**Activity Data (TJ)**
2013	26.9	2015	20.6	2017	NE
2014	17.1	2016	NE		

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

A 100% default value provided in the 2006 IPCC Guidelines was applied for the uncertainty of emission factors; a 5% default value provided in the 2006 IPCC Guidelines was applied for the uncertainty of the activity data. As a result, the uncertainty of emissions was assessed to be 100%.

- ***Time-series Consistency***

The Statics Office of Georgia started the production of energy balance in 2013. Emissions for the period of 2013 and 2015 are consistently estimated using the activity data provided by the Statistics Office of Georgia.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the2006 IPCC Guidelines. General inventory QC focuses on checking of the parameters for activity data and emission factors and archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculations have not been applied for this submission.

f) Category-specific Planned Improvements

Georgia is going to advance these assumptions by addressing its national circumstances and to provide relevant information in its forthcoming submissions in accordance with the study of the source-category

[89]2006 IPCC Guidelines for National Greenhouse Gas Inventories Vol.3 Chapter 5, p.5.12

under the project: “Georgia’s Integrated Transparency Framework for Implementation of Paris Agreement”.

4.5.3. Solvent Use (2.D.3.)

This source category does not exist in Georgia.

4.5.4. Other (2.D.4.)

4.5.4.1. Asphalt Production and Use

a) Source-category description and calculated emissions

Georgia is mainly producing artificial asphalt. The calculated carbon monoxide and NMVOCs emissions from asphalt production are presented in *Table 4-32*.

Table 4-32 CO and NMVOCs emissions from asphalt production in 1990-2017

Year	Asphalt-concrete production	Emission factor (t CO /Gg asphalt)	CO emission (t)	CO emission (Gg)	Emission factor (t NMVOCs /Gg asphalt)	NMVOCs emission (t)	NMVOCs emission (Gg)
1990	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO	NO
1996	NO	NO	NO	NO	NO	NO	NO
1997	21.9	0.0095	0.21	0.0002	0.0475	1.04	0.0010
1998	20.9	0.0095	0.20	0.0002	0.0475	0.99	0.0010
1999	10.0	0.0095	0.10	0.0001	0.0475	0.48	0.0005
2000	19.7	0.0095	0.19	0.0002	0.0475	0.94	0.0009
2001	24.7	0.0095	0.23	0.0002	0.0475	1.17	0.0012
2002	25.1	0.0095	0.24	0.0002	0.0475	1.19	0.0012
2003	70.6	0.0095	0.67	0.0007	0.0475	3.35	0.0034
2004	117.5	0.0095	1.12	0.0011	0.0475	5.58	0.0056
2005	293.4	0.0095	2.79	0.0028	0.0475	13.94	0.0139
2006	228.4	0.0095	2.17	0.0022	0.0475	10.85	0.0108
2007	189.1	0.0095	1.80	0.0018	0.0475	8.98	0.0090
2008	183.2	0.0095	1.74	0.0017	0.0475	8.70	0.0087
2009	181.4	0.0095	1.72	0.0017	0.0475	8.62	0.0086
2010	371.6	0.0095	3.53	0.0035	0.0475	17.65	0.0177
2011	173.3	0.0095	1.65	0.0016	0.0475	8.23	0.0082
2012	444.4	0.0095	4.22	0.0042	0.0475	21.11	0.0211
2013	464.6	0.0095	4.41	0.0044	0.0475	22.07	0.0221
2014	325.4	0.0095	3.09	0.0031	0.0475	15.46	0.0155
2015	627.4	0.0095	5.96	0.0060	0.0475	29.80	0.0298
2016	815.9	0.0095	7.75	0.0078	0.0475	38.76	0.0388
2017	866.2	0.0095	8.23	0.0082	0.0475	41.15	0.0411

b) Methodological Issues

- ***Estimation Method***

The methodology used in the IPCC 1996 has been applied, according to which only NMVOCs and CO emissions will be considered in this sub-sector, since it is believed that the direct effects of the greenhouse gas emissions from asphalt production is negligible. Emission rate is calculated by emission factors (gases emitted during production of a tonne of asphalt) multiplied by tonnes of produced asphalt.

- ***Emission Factors***

Emissions from asphalt production are calculated on the national level only for CO and NMVOCs. Emission factors are taken from the EMER / CORINAIR (SNAP 40610) guidelines,[90] The technology of the asphalt production - saturation without emission. for NMVOCs - 0.0475, while for CO - 0.0095 kg / tonne of asphalt.

- ***Activity data***

This sub-sector considers asphalt producing enterprises (oil refineries are not included) and its consumption. In Georgia asphalt production technology is as follows: after processing of oil products the remaining mass Bitumen and fillers (cement, lime) are stirred in mobile or stationary units about 30-50 km away from the place where asphalt is used. Asphalt products are also used as binder and hermetic material, for example for foundations, etc. Asphalt surface for roads is condensed, contains compact fillers and bitumen connecting. Liquid asphalt is characterized by a relatively high level of emissions. There are bitumen and asphalt emulsions. The latter is mainly composed of water and a small or zero amounts of solvents. During the discussed period in Georgia the main volume of asphalt was produced by several large and small enterprises. They produced the so-called hot asphalt mixture using almost the same technology. The data has been provided by Georgian statistics office.

4.6. Electronics industry (2.E.)

This source category does not exist in Georgia.

4.6.1. Semiconductor (2.E.1.)

This source category does not exist in Georgia.

4.6.2. Liquid Crystals (2.E.2.)

This source category does not exist in Georgia.

4.6.3. Photovoltaics (2.E.3.)

This source category does not exist in Georgia.

4.6.4. Heat transfer fluid (2.E.4.)

This source category does not exist in Georgia.

4.7. Product uses as substitutes for ODS (2.F.)

The Sub-sector of the Product uses as substitutes for ODS in Georgia covers HFC and PFC emissions from the Refrigeration and air conditioning (2.F.1). In 2017 the GHG emissions from the sub-sector of the

---

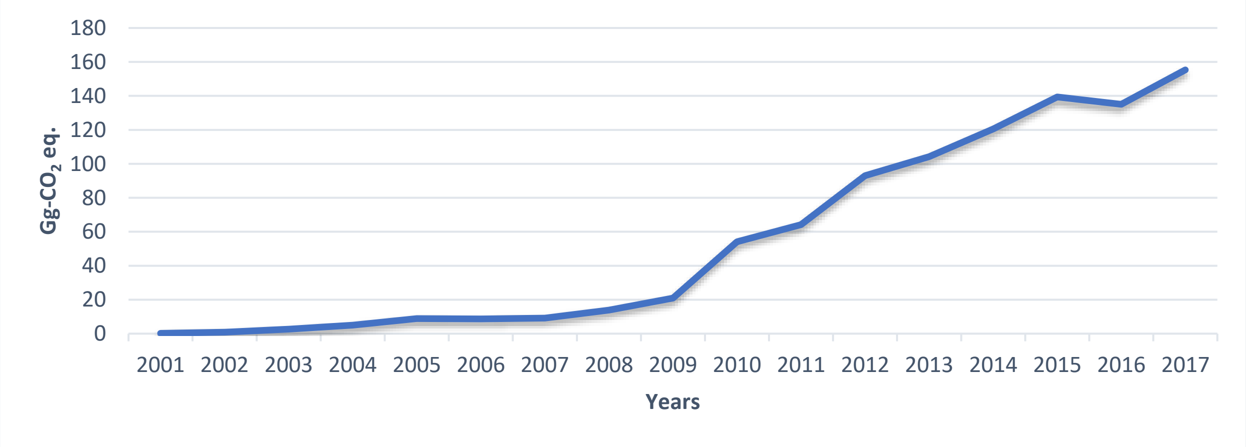
[90] EMEP/CORINAR (SNAP A0 610), Atmosperic emission inventory guidebook. Second edition 2009. http://eea.europa.eu/publications/Emep CORINARS 5

Product uses as substitutes for ODS was 7.8% of the total emissions from the Industrial Processes and Product use.

Nowadays, the industrial gases (hydrofluorocarbons -HFCs, perfluorocarbons -PFCs and Sulphur hexafluoride -SF6) are only imported for utilization. Accordingly, the emissions are only specified by their usage. Calculation of halocarbons is important as they are characterized by stability and high global warming potential (GWP).

The emissions trend is illustrated in the *Figure 4-5* beneath.

Figure 4-5 The emissions trend from the Product uses as substitutes for ODS



4.7.1. Refrigeration and Air Conditioning Equipment (2.F.1.)

a) Source-category description and calculated emissions

The emissions from the consumption of HFCs have been estimated based on the halogens imported to Georgia. These compounds and mixtures are: HFC-134a, R-404A, R-407C, R-507A, R-410A. The composition analysis of these mixtures reveals that mostly four different compounds of HFCs are accounted for in the period between 2001 and 2015. The emissions from the HFCs consumption counts from the year of 2001 due to the appearance in imported goods.

In general, the emission from the HFCs consumption has an upward trend in Georgia. The highest emissions were in 2017 - about 155 Gg CO_2 eq. In 2014 the emissions were 14 per cent lower than in 2015. The lowest emissions from the HFCs consumption in Georgia were estimated in 2001 - 0.2 Gg of CO_2 eq. - almost 700 times less compared to the end of the period.

The actual emissions from the f-gases in Refrigerators and Air conditioners are represented in the *Table 4-33, Table 4-34, Table 4-35, Table 4-36* beneath.

Table 4-33 HFC-134a actual emissions in Georgia in 2001-2017

Year	Quantity of Pollutant (t)	GWP	CO_2 eq. (Gg)	Year	Quantity of Pollutant (t)	GWP	CO_2 eq. (Gg)
2001	0.08	1300	0.11	2010	20.31	1300	26.41
2002	0.36	1300	0.46	2011	23.49	1300	30.54
2003	1.13	1300	1.46	2012	43.67	1300	56.77
2004	1.87	1300	2.43	2013	50.06	1300	65.07
2005	3.53	1300	4.59	2014	52.60	1300	68.38
2006	3.61	1300	4.69	2015	59.87	1300	77.83
2007	4.09	1300	5.31	2016	56.28	1300	73.16
2008	6.01	1300	7.81	2017	62.84	1300	81.69

2009	9.88	1300	12.84				

Table 4-34 HFC-125 actual emissions in Georgia in 2001-2017

Year	Quantity of Pollutant (t)	GWP	CO_2 eq. (Gg)	Year	Quantity of Pollutant (t)	GWP	CO_2 eq. (Gg)
2001	0.02	2800	0.05	2010	4.59	2800	12.86
2002	0.07	2800	0.19	2011	6.18	2800	17.31
2003	0.23	2800	0.64	2012	6.81	2800	19.06
2004	0.51	2800	1.42	2013	7.62	2800	21.33
2005	0.83	2800	2.33	2014	10.97	2800	30.71
2006	0.79	2800	2.22	2015	13.43	2800	37.61
2007	0.76	2800	2.14	2016	14.34	2800	40.16
2008	1.10	2800	3.09	2017	17.44	2800	48.85
2009	1.45	2800	4.07				

Table 4-35 HFC-143a actual emissions in Georgia in 2001-2017

Year	Quantity of Pollutant (t)	GWP	CO_2 eq. (Gg)	Year	Quantity of Pollutant (t)	GWP	CO_2 eq. (Gg)
2001	0.02	3800	0.06	2010	3.66	3800	13.91
2002	0.05	3800	0.20	2011	3.83	3800	14.54
2003	0.12	3800	0.47	2012	3.95	3800	15.01
2004	0.26	3800	0.99	2013	4.01	3800	15.24
2005	0.46	3800	1.73	2014	4.46	3800	16.94
2006	0.40	3800	1.53	2015	4.73	3800	17.98
2007	0.38	3800	1.45	2016	3.84	3800	14.61
2008	0.71	3800	2.71	2017	4.19	3800	15.92
2009	0.95	3800	3.61				

Table 4-36 HFC-32 actual emissions in Georgia in 2001-2017

Year	Quantity of Pollutant (t)	GWP	CO_2 eq. (Gg)	Year	Quantity of Pollutant (t)	GWP	CO_2 eq. (Gg)
2001	0.00[91]	650	0.00[92]	2010	1.37	650	0.89
2002	0.02	650	0.01	2011	2.79	650	1.82
2003	0.11	650	0.07	2012	3.30	650	2.14
2004	0.26	650	0.17	2013	4.03	650	2.62
2005	0.41	650	0.27	2014	6.96	650	4.52
2006	0.42	650	0.27	2015	9.18	650	5.97
2007	0.41	650	0.26	2016	10.96	650	7.13
2008	0.46	650	0.30	2017	13.65	650	8.87
2009	0.60	650	0.39				

b) *Methodological Issues*

- ***Estimation Method***

According to the IPCC 2006 Guideline the Tier 1a/b method was used for estimation of actual emissions. The spreadsheet contained in the 2006 Guidelines has been used for the calculations.

In accordance with the national circumstances of Georgia there is no domestic production of HFCs so far. Subsequently, production is zero. There is the same situation in relation of export. Accordingly, the

[91] 0.00345
[92] 0.00224

emissions from the sub-sector of Consumption of Halocarbons correspond to the imported gases and equipment mostly for the air conditioning and refrigerants.

- ***Emission Factors***

According to the IPCC 2000 GPG, the imported or produced halocarbons and perfluorocarbons are emitted completely and consequently their emission coefficient is equal to 1.

- ***Activity data***

Since the Customs Service possesses the most accurate data on imported goods, the data on the HFC gases are obtained from the above agency. The aggregated values were separated in 4 different compounds: HFC-134a, HFC-125, HFC-143a, and HFC-32 by the expert judgment (Table 4-37, Table 4-38, Table 4-39, and Table 4-40).

Table 4-37. Imported data of HFC-134a

Imported HFC-134a					
Year	**Activity Data (t)**	**Year**	**Activity Data (t)**	**Year**	**Activity Data (t)**
2001	70.52	2007	6.80	2013	70.52
2002	65.78	2008	16.92	2014	65.78
2003	0.24	2009	31.80	2014[93]	0.24
2004	73.92	2010	79.44	2015	73.92
2005	89.55	2011	39.05	2016	89.55
2006	92.25	2012	152.19	2017	92.25

Table 4-38. Imported data of HFC-125

Imported HFC-125					
Year	**Activity Data (t)**	**Year**	**Activity Data (t)**	**Year**	**Activity Data (t)**
2001	0.11	2007	0.60	2013	8.77
2002	0.35	2008	3.03	2014	26.10
2003	1.14	2009	3.44	2014[94]	0.18
2004	2.08	2010	22.39	2015	25.41
2005	2.67	2011	14.68	2016	35.22
2006	0.59	2012	9.31	2017	35.37

Table 4-39. Imported data of HFC-143a

Imported HFC-143a					
Year	**Activity Data (t)**	**Year**	**Activity Data (t)**	**Year**	**Activity Data (t)**
2001	0.10	2007	0.26	2013	3.22
2002	0.26	2008	2.60	2014	4.91
2003	0.52	2009	2.29	2014[95]	0.08
2004	1.04	2010	19.02	2015	4.39
2005	1.56	2011	4.31	2016	5.99
2006	0.10	2012	3.98	2017	6.14

[93] destroyed amount of HFC-134a
[94] destroyed amount of HFC-134a
[95] destroyed amount of HFC-134a

Table 4-40. Imported data of HFC-32

Imported HFC-32					
Year	**Activity Data (t)**	**Year**	**Activity Data (t)**	**Year**	**Activity Data (t)**
2001	0.02	2007	0.35	2013	5.90
2002	0.12	2008	0.76	2014	21.62
2003	0.64	2009	1.38	2014[96]	0.11
2004	1.10	2010	5.75	2015	21.39
2005	1.24	2011	10.76	2016	29.73
2006	0.46	2012	5.72	2017	29.74

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the activity data, the 10% value of the Tier 1 method for metal industry provided in the *2006 IPCC Guidelines* was applied for all production, use, and disposal. As a result, the uncertainties of the emissions were determined to be 32% for production and use and 10% - for disposal.

- ***Time-series Consistency***

Emissions throughout the time series are consistently estimated using the activity data provided by the refrigerant's association.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the2006 IPCC Guidelines. The focus of general inventory QC is made on checking of the parameters for activity data and emission factors and archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculations have not been applied for this submission.

f) Category-specific Planned Improvements

Georgia is going to advance these assumptions by addressing its national circumstances and to provide relevant information in its forthcoming submissions in accordance with the study of the source-category under the project: "Georgia's Integrated Transparency Framework for Implementation of Paris Agreement".

4.7.2. Foam Blowing Agents (2.F.2.)

The emissions from this source-category is going to be estimated using the methods delivered under the project: "Georgia's Integrated Transparency Framework for Implementation of the Paris Agreement" for the period of 2020-2022.

4.7.3. Fire Protection (2.F.3.)

The emissions from this source-category is going to be estimated using the methods delivered under the project: "Georgia's Integrated Transparency Framework for Implementation of the Paris Agreement" for the period of 2020-2022.

4.7.4. Aerosols (2.F.4.)

[96] destroyed amount of HFC-134a

The emissions from this source-category is going to be estimated using the methods delivered under the project: “Georgia’s Integrated Transparency Framework for Implementation of the Paris Agreement” for the period of 2020-2022.

4.7.5. Solvents (2.F.5.)

The emissions from this source-category is going to be estimated using the methods delivered under the project: “Georgia’s Integrated Transparency Framework for Implementation of the Paris Agreement for the period of 2020-2022.

4.7.6. Other applications (2.F.6.)

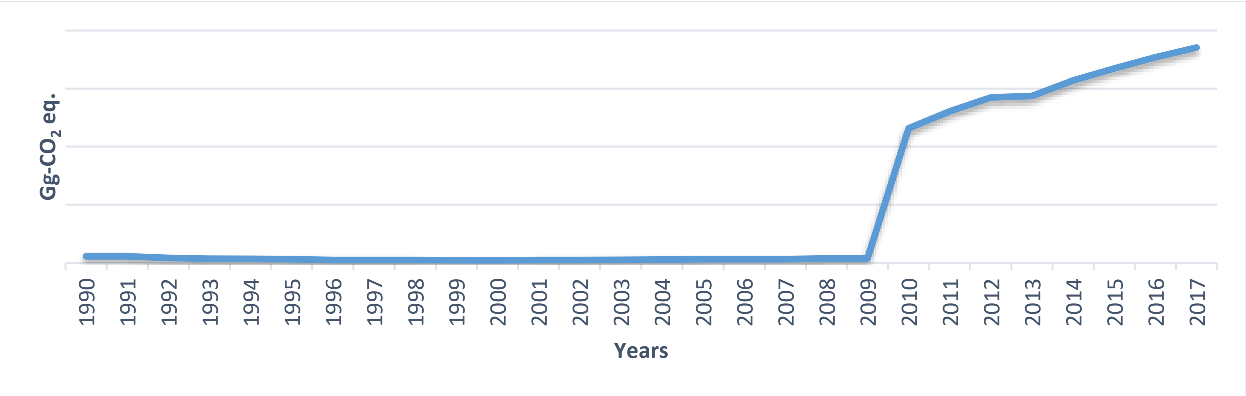
In case of relevance the emissions from this source-category is going to be estimated using the methods delivered under the project: “Georgia’s Integrated Transparency Framework for Implementation of the Paris Agreement” for the period of 2020-2022.

4.8. Other product manufacture and use (2.G.)

The Sub-sector of the Other product manufacture and use in Georgia considers emissions from the Electrical Equipment (2.G.1) and N_2O from product uses (2.G.3) source-categories. In 2017 the GHG emissions from the sub-sector of the other product manufacture and use was 0.02% of the total emissions from the Industrial Processes and Product use.

The emissions trend is illustrated in the *Figure 4-6* beneath.

Figure 4-6 The emissions trend from the other product manufacture and use



4.8.1. Electrical Equipment (2.G.1.)

a) Source-category description and calculated emissions

Only SF_6 equipment was operated in Georgia during the reporting period. At energy facilities SF_6 is used in communication equipment. According to official information provided by the State Electricity specialists, namely, they were installed since 1997 at various voltage breakers. Currently number of "Elegas Breakers" on the balance of JSC "GSE" consists of 304 sets, and the total volume of SF_6 in them is C kg. The equipment used in breakers is hermetic; their operational lifetimes 30-40 years. It should be noted that according to experts reports in recent years, quality (hermitization) of this type of equipment has significantly improved, which means that SF_6 emissions from electric utilities were subsequently reduced (50-90%). . Amount of SF_6 released in Georgia during working processes of electrical equipment is calculated for 1997-2013. The results of calculations are presented in *Table 4-41* below.

Table 4-41 SF_6 quantities released from electrical equipment in Georgia in 2010-2017

Year	Consumed SF_6, tons	Rate of SF_6 losses	SF_6 emission, tons	SF_6 emission, Gg	SF_6 emission, Gg CO_2eq.
2010	C	0.002	C	C	C
2011	C	0.002	C	C	C
2012	C	0.002	C	C	C
2013	C	0.002	C	C	C
2014	C	0.002	C	C	C
2015	C	0.002	C	C	C
2016	C	0.002	C	C	C
2017	C	0.002	C	C	C

Calculations demonstrated that SF_6 emission from using equipment in energy system of Georgia is practically insignificant. The emission reached its maximum in 2015 and amounted to C Gg or C Gg CO_{2eq}.

b) *Methodological Issues*

- ***Estimation Method***

For calculation of SF_6 emission the Methodology from IPCC-2006 Guideline was used as it provides the spreading coefficients according to the regions and to the types of devices (airproof, closed).

- ***Emission Factors***

According to the IPCC 2006, the following coefficients are provided for the specific types of devices and according to the regions in the *Table 4-42* beneath.

Table 4-42 The coefficients of SF_6 emissions according to the regions and to the types of devices

Region/ Phase	Airproof / leakage per year, %	Closed / leakage per year, %
Europe	0.002	0.026

- ***Activity data***

Statistics of installed SF_6 breakers in JSC "Georgian State Electro system" from 2010-2017 is presented in Table *4-43*.

Table 4-43 Number of breakers that contain SF_6 installed in the state electricity system in 2010-2017

Year	2010	2011	2012	2013	2014	2015	2016	2017
Amount	85	31	14	1	15	21	14	12

c) *Uncertainties and Time-series Consistency*

- ***Uncertainty***

For the uncertainties of the activity data, the 10% value of the Tier 1 method for Electrical Equipment in the *2006 IPCC Guidelines* was applied for all production, use, and disposal. As a result, the uncertainties of the emissions for production and use were determined to be 32%, and for disposal- 10%.

- ***Time-series Consistency***

Emissions throughout the time series are consistently estimated using the activity data provided by the JSC “GSE”.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the2006 IPCC Guidelines. The focus of general inventory QC is made on checking of the parameters for activity data and emission factors and archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculations have not been applied for this submission.

f) Category-specific Planned Improvements

Georgia is going to advance these assumptions by addressing its national circumstances and to provide relevant information in its forthcoming submissions in accordance with the study of the source-category under the project: "Georgia's Integrated Transparency Framework for Implementation of Paris Agreement".

4.8.2. SF6 and PFCs from other product use (2.G.2.)

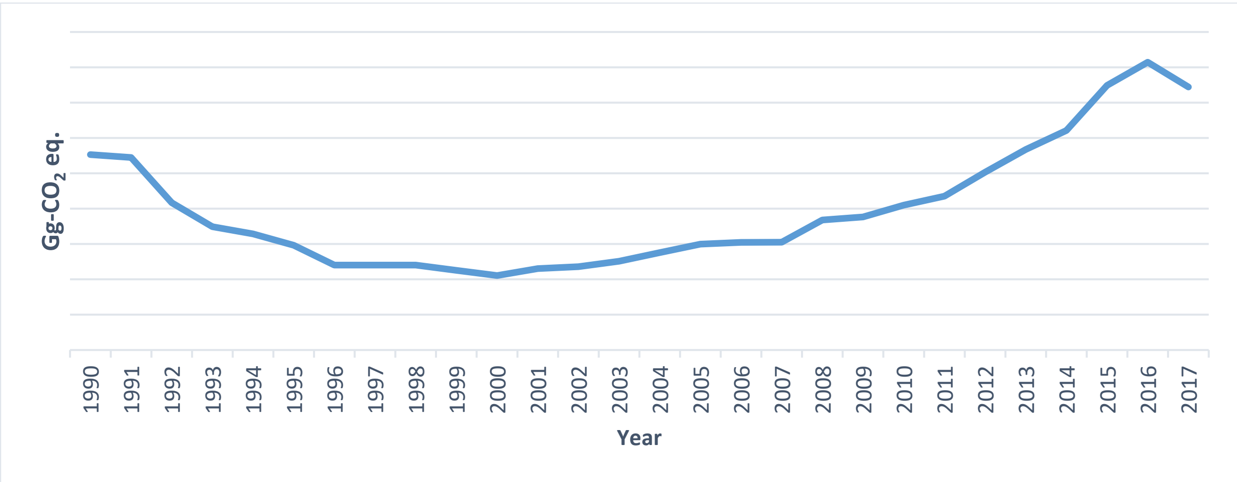
The emissions from this source-category is going to be estimated by using the methods delivered under the project: "Georgia's Integrated Transparency Framework for Implementation of the Paris Agreement" for the period of 2020-2022.

4.8.3. N_2O from product uses (2.G.3.)

a) Source-category description and calculated emissions

In general, one of major sources of greenhouse gas emissions is solvents and their associated components. This sector considers nitrous oxide (N_2O) emissions, the main source of its use being anesthesia in the medical field.

Figure 4-7 The emissions from the Solvent and Other Product Use



Average annual emissions of N_2O used for anesthesia in Healthcare system during the discussed period amounted to C Gg/year, or slightly less.

N_2O emissions in 2010-2017 in this subsector are estimated specifically for anesthesia in medical field. Nitrogen monoxide (N_2O) emissions are released from various sources (agriculture, industry, transport) and one of the fields, which also contribute to the emission of nitric oxide, is Healthcare system.

Nitrogen monoxide-containing substances are most actively used during anesthesia in medical sector. In addition, most inhalational anesthetics contain N_2O.

Table 4-44 Emission of N_2O from the subsector "Solvents and other product use" in 1990-2017

Year	Number of medical operations conducted	EF (kg N_2O /per surgery)	N_2O emission (Gg)	CO_2 eq. emission (Gg)
1990	C	1.96E-04	C	C
1991	C	1.96E-04	C	C
1992	C	1.96E-04	C	C
1993	C	1.96E-04	C	C
1994	C	1.96E-04	C	C
1995	C	1.96E-04	C	C
1996	C	1.96E-04	C	C
1997	C	1.96E-04	C	C
1998	C	1.96E-04	C	C
1999	C	1.96E-04	C	C
2000	C	1.96E-04	C	C
2001	C	1.96E-04	C	C
2002	C	1.96E-04	C	C
2003	C	1.96E-04	C	C
2004	C	1.96E-04	C	C
2005	C	1.96E-04	C	C
2006	C	1.96E-04	C	C
2007	C	1.96E-04	C	C
2008	C	1.96E-04	C	C
2009	C	1.96E-04	C	C
2010	C	1.96E-04	C	C
2011	C	1.96E-04	C	C
2012	C	1.96E-04	C	C
2013	C	1.96E-04	C	C
2014	C	1.96E-04	C	C
2015	C	1.96E-04	C	C
2016	C	1.96E-04	C	C
2017	C	1.96E-04	C	C

b) *Methodological Issues*

- ***Estimation Method***

Calculations assumed that N_2O used for anesthesia is fully emitted into the atmosphere or, in other words, emission of N_2O is equal to its use.

It was assumed that consumed N_2O is proportional to a total number of surgical operations conducted in the country. These data and the results of the calculations are presented in *Table 4-45*.

- ***Emission Factor***

Emission factor is 0.196*10-3 kg[97].

- ***Activity data***

[97] EMEP/CORINAR (EEA-2009); (page 5.18, Table 8.11- coefficients for European countries)

Surgery visits in Georgia during the period of 1990-2017were used for calculation; the information was provided by the Ministry of Health and Social Security and National Statistics Office of Georgia. The number of medical operations is represented in the Table 4-45.

Table 4-45. Number of medical operations

Medical operations					
Year	**Activity Data (t)**	**Year**	**Activity Data (t)**	**Year**	**Activity Data (t)**
1990	C	2000	C	2010	C
1991	C	2001	C	2011	C
1992	C	2002	C	2012	C
1993	C	2003	C	2013	C
1994	C	2004	C	2014	C
1995	C	2005	C	2015	C
1996	C	2006	C	2016	C
1997	C	2007	C	2017	C
1998	C	2008	C		
1999	C	2009	C		

4.8.3.1. Medical applications (2.G.3.a)

4.8.3.2. Other (2.G.3.b)

4.9. Other (2.H.)

a) Source-category description and calculated emissions

This category includes production of pulp and paper (2.H.1), as well as of food and drinks (2.H.2). Presently there is no wood processing in Georgia. The paper is produced in Tserovani Plant, but it uses imported raw materials and this production does not cause the GHG emissions into the atmosphere.

4.9.1. Food and beverages industry (2.H.2.)

The direct greenhouse gases are not produced from the source category of Food and Drinks Production and therefore only indirect gases and NMVOCs were estimated. Various enterprises of food industry operated in Georgia during the discussed period; the major ones among them were: meat and fish processing, corn drying and milling, bakery, confectionary, sugar, wine, spirit, beer, soft drinks, dairy products, coffee roasting and milling. The non-methane volatile organic compounds emissions (NMVOCs) from just this subcategory are calculated here.

The emissions calculated based on statistical data provided in this subsector and on the emission, factors offered by the methodological instructions of IPCC 1996, are given in the Table 3-28.

According to the conducted calculations it is obvious that the volume of NMVOCs released into the atmosphere from foods and drinks production at the territory of Georgia during 1990-2015 is significant and 200 times exceeds the emissions from the asphalt production (see the *Table 4-46*).

Table 4-46. NMVOCs Emissions from The Food and Drinks Production in 1990-2017 in Georgia (Gg)

Year	Meat and semi-prepared meat food (t)	Fish and fish product (t)	Margarine and similar products (t)	Drying and grinding of wheat (t)	Bread baking (t)	Confectionary (t)	Sugar (t)	Milling and roasting of coffee (t)	Forage for domestic animals (t)	Sparkling wine (hl)	White wine (hl)	Beer (hl)	Spirit, vodka (hl)	Brandy (hl)
1990	0.0133	0.0179	C	1.2372	8.5557	0.0595	C	NO	1.0797	0.00012	0.0006	0.0003	0.0123	0.0076
1991	0.0044	0.0120	C	1.1008	10.0493	0.0253	C	NO	0.8385	0.00009	0.0004	0.0002	0.0116	0.0051
1992	0.0014	0.0007	C	0.7521	7.6031	0.0019	C	NO	0.3467	0.00006	0.0007	0.0001	0.0097	0.0048
1993	0.0002	0.0001	C	0.6013	6.3951	0.0019	C	NO	0.1611	0.00004	0.0005	0.0000	0.0178	0.0036
1994	0.0001	0.0001	C	0.5465	4.9833	0.0005	C	NO	0.1356	0.00001	0.0002	0.0000	0.0034	0.0010
1995	0.0001	0.0002	C	0.4346	2.9635	0.0003	C	NO	0.0843	0.00000	0.0001	0.0000	0.0022	0.0006
1996	0.0001	0.0002	C	0.2747	2.6230	0.0004	C	0.0005	0.0374	0.00001	0.0001	0.0000	0.0029	0.0005
1997	0.0003	0.0004	C	0.2342	1.9866	0.0002	C	0.0017	0.0220	0.00001	0.0001	0.0000	0.0065	0.0003
1998	0.0003	0.0000	C	0.1918	1.7389	0.0003	C	0.0009	0.0110	0.00000	0.0001	0.0000	0.0041	0.0001
1999	0.0004	0.0000	C	0.1482	1.1359	0.0002	C	0.0008	0.0048	0.00001	0.0001	0.0000	0.0077	0.0001
2000	0.0003	0.0000	C	0.1339	1.1134	0.0001	C	0.0008	0.0027	0.00001	0.0001	0.0001	0.0078	0.0002
2001	0.0001	0.0000	C	0.1037	0.8814	0.0001	C	0.0006	0.0001	0.00001	0.0001	0.0001	0.0109	0.0003
2002	0.0002	0.0000	C	0.1013	0.8884	0.0001	C	0.0002	0.0000	0.00001	0.0001	0.0001	0.0043	0.0003
2003	0.0003	0.0000	C	0.0939	0.7701	0.0003	C	0.0003	0.0013	0.00001	0.0001	0.0001	0.0058	0.0005
2004	0.0007	0.0000	C	0.1829	1.0013	0.0003	C	0.0003	0.0007	0.00001	0.0001	0.0002	0.0161	0.0007
2005	0.0008	0.0001	C	0.2545	0.9294	0.0003	C	0.0005	0.0006	0.00002	0.0001	0.0002	0.0200	0.0008
2006	0.0012	0.0000	C	0.3997	0.8390	0.0007	C	0.0007	0.0156	0.00001	0.0001	0.0003	0.0172	0.0005
2007	0.0018	0.0001	C	0.4696	0.8244	0.0009	C	0.0005	0.0484	0.00001	0.0001	0.0002	0.0139	0.0003
2008	0.0023	0.0001	C	0.2837	0.6746	0.0017	C	0.0003	0.0098	0.00001	0.0001	0.0002	0.0147	0.0005
2009	0.0017	0.0003	C	0.4977	0.8085	0.0020	C	0.0006	0.0080	0.00001	0.0000	0.0002	0.0189	0.0004
2010	0.0030	0.0003	C	0.5219	1.2609	0.0065	C	0.0011	0.0032	0.00001	0.0001	0.0003	0.0214	0.0003
2011	0.0046	0.0006	C	0.6226	1.4564	0.0146	C	0.0013	0.0034	0.00001	0.0001	0.0003	0.0245	0.0008
2012	0.0062	0.0005	C	0.6350	1.3521	0.0153	C	0.0014	0.0056	0.00001	0.0002	0.0003	0.0262	0.0012
2013	0.0079	0.0004	C	0.5728	1.5141	0.0156	C	0.0014	0.0067	0.00001	0.0002	0.0004	0.0294	0.0008
2014	0.0083	0.0006	C	0.5817	1.6456	0.0163	C	0.0012	0.0169	0.00001	0.0004	0.0003	0.0213	0.0010
2015	0.0086	0.0006	C	0.5567	1.5941	0.0176	C	0.0013	0.0191	0.00001	0.0003	0.0003	0.0143	0.0011
2016	0.0100	0.0006	C	0.5163	2.0146	0.0211	C	0.0016	0.0158	0.00001	0.0003	0.0004	0.0247	0.0013
2017	0.0106	0.0006	C	0.5755	1.9033	0.0260	C	0.0019	0.1636	0.00003	0.0003	0.0003	0.0256	0.0032

In this sector the food production is the major emitter of NMVOCs, contributing to approximately 98% of the total volume of emitted NMVOCs.

b) Methodological Issues

- ***Estimation Method***

It is recommended to conduct the calculations according to Tier 2 approach, that provides taking into consideration the production technology designed for each separate product. As for Tier 3 approach, it implies including the modeling into the calculation process. The Tier 2 approach was applied for calculations.

- ***Emission Factors***

The emission coefficients offered in the IPCC Guidelines are provided in the Table 23 and are calculated based on the following assumptions:

- 0.15 tonne of grains is consumed for producing of 1-tonne beer;
- Brandy fermentation takes 3 years, but other alcohol drinks do not require fermentation;
- It is assumed that content of alcohol in the beer is 4%, , provided the mass of 1m3 is 1 tonne;
- The spirit has 40% of alcohol content;
- The density of the ethyl alcohol is 789 kg/m3.

Table 4-47. Coefficients of NMVOCs Emissions for the Subcategory "Food and Drinks Production"

Food	EF kg NMVOCs/t food production	Beverages	EF Kg NMVOCs/hl drink production
Meat and meat semi-prepared food	0.3	Sparkling wine	0.080
Fish and fish product	0.3	White wine	0.035
Margarine and similar products	10.0	Beer	0.035
Drying and grinding of wheat	1.3	Spirit, vodka	15.000
Bread baking	10.0	Brandy	3.500
Confectionary	1.0	Alcohol free drinks	0.400
Sugar	10.0		
Milling and roasting of coffee	0.6		
Forage for domestic animals	1.0		

- ***Activity Data***

The subsector of food and drinks production comprises the complete cycle of food production: thermal processing of fats, baking, fermentation, cooking, drying, corn drying and milling processes. These activities imply emission of various volatile compounds, but only NMVOCs emissions will be discussed here according to the IPCC Methodological Guidelines. The emissions from processing of dairy products or oils are not discussed in this sector, as their processing technologies do not require heating, and consequently the emissions are not significant. In drinks (beer, wine, alcohol) production uses grapes, fruits and corn, which should be matured prior to being processed. During this process, the starch is turned into sugar and the sugar turns into the ethyl spirit with participation of yeast microbes. This process is called fermentation. Sometimes the technological process requires preparing raw materials before the fermentation (for example, for beer production, preparing of malt, for spirit production – distillation of the fermented liquid). The technological process of preparing food products and drinks includes roasting of raw materials, fermentation, and distillation. The fermentation process determines the sugar content of drinks and is the main cause of the emission of NMVOCs.

Table 4-48 demonstrates the data on the food production in Georgia during 1990-2017.

Table 4-48. The Food Products (tonne) and Drinks Produced in Georgia in 1990-2017

Year	Meat and semi-prepared meat food (t)	Fish and fish product (t)	Margarine and similar products (t)	Drying and grinding of wheat (t)	Bread baking (t)	Confectionary (t)	Sugar (t)	Milling and roasting of coffee (t)	Forage for domestic animals (t)	Sparkling wine (hl)	White wine (hl)	Beer (hl)	Spirit, vodka (hl)	Brandy (hl)
1990	44235	59678	C	951699	855572	59504	C	NO	1079685	1451	16283	9477	822	2165
1991	14728	39901	C	846748	1004925	25281	C	NO	838505	1104	12616	6011	774	1460
1992	4509	2190	C	578534	760311	1924	C	NO	346695	779	21011	2352	647	1358
1993	555	386	C	462506	639512	1859	C	NO	161144	443	14003	1204	1187	1023
1994	246	188	C	420421	498331	466	C	NO	135550	171	7000	632	229	282
1995	235	518	C	334288	296351	346	C	NO	84303	49	4229	653	145	158
1996	410	622	C	211346	262305	378	C	784	37406	95	2697	476	196	135
1997	938	1457	C	180183	198657	235	C	2830	22045	76	3600	785	435	82
1998	1155	31	C	147529	173886	277	C	1484	11034	40	2304	971	271	38
1999	1423	3	C	113980	113590	154	C	1318	4811	67	1939	1258	514	31
2000	995	63	C	102977	111335	144	C	1411	2701	88	1665	2345	522	71
2001	417	13	C	79734	88141	101	C	997	99	115	1976	2572	729	73
2002	603	4	C	77900	88842	105	C	349	NE	118	2012	2735	286	74
2003	1011	10	C	72215	77009	336	C	418	1318	160	2308	2842	388	142
2004	2261	57	C	140688	100126	287	C	483	691	164	2666	4762	1071	193
2005	2640	299	C	195754	92938	348	C	758	603	189	3906	5864	1337	227
2006	3965	155	C	307454	83899	656	C	1204	15599	137	2118	7337	1147	152
2007	5842	457	C	361223	82443	885	C	796	48389	162	1438	7087	927	87
2008	7830	259	C	218256	67460	1669	C	466	9773	160	1670	6246	977	151
2009	5815	943	C	382884	80853	2016	C	1073	7995	122	1400	6854	1261	124
2010	9987	1002	C	401483	126086	6464	C	1889	3207	114	2476	8279	1427	100
2011	15353	2152	C	478916	145640	14560	C	2207	3446	139	2905	7874	1634	226
2012	20537	1507	C	488460	135211	15345	C	2401	5628	124	4499	9903	1748	338

Year	Meat and semi-prepared meat food (t)	Fish and fish product (t)	Margarine and similar products (t)	Drying and grinding of wheat (t)	Bread baking (t)	Confectionary (t)	Sugar (t)	Milling and roasting of coffee (t)	Forage for domestic animals (t)	Sparkling wine (hl)	White wine (hl)	Beer (hl)	Spirit, vodka (hl)	Brandy (hl)
2013	26492	1375	C	440589	151412	15596	C	2411	6720	165	6552	10090	1963	229
2014	27773	1970	C	447428	164562	16339	C	1956	16894	181	10869	9965	1421	286
2015	28544	2005	C	428262	159409	17598	C	2167	19139	128	7554	8606	950	323
2016	33303	2049	C	397152	201457	21103	C	2731	15787	160	9001	10238	1644	362
2017	35346	2145	C	442715	190334	25991	C	3157	163646	353	8702	8849	1709	912

Agriculture (CRF Sector 3)

4.10. Overview of Sector

This chapter provides the information about the estimation of greenhouse gas (GHG) emissions from Agriculture Sector for the period 1990-2017.

According to the "Agriculture census 2014", in Georgia 73.1% of farms manage land lots up to 1 ha, 25% land lots from 1 ha to 5 ha and only 1.5% of the farms manage land lots larger than 5 ha. The agricultural lands area of Georgia comprises 2.55 million hectares, which is about 37% of the total territory (forestry is about 41%, other area - about 23%). The shares of various agricultural activities are as follows: Land under annual crops – 220,300 ha, Permanent cropland – 226,100 ha, Pastures, and grasslands - 1,776,000 ha.

The agriculture sector of Georgia as source of GHG emissions comprises three subcategories: Enteric fermentation, Manure management and Agricultural Soils. The other IPCC subcategories of rice cultivation and prescribed burning of savannas are not relevant for Georgia and therefore are not considered. GHG emissions are estimated for 2016-2017 years period. For previous 1990-2015 years GHG emissions from agriculture sectors are recalculated applying specified data on cattle distribution by breeds (provided by Head of the Department of Zootechny of the Agrarian University of Georgia Mr. Levan Tortladze), using tier 2 approach for methane emissions from manure management, estimating GHG emissions from enteric fermentation in donkeys and horses (during 2006-2017 years) and estimating GHG emissions from field burning of agricultural residues.

The GHG emissions from the agricultural sector are presented in *Table 4-49,* and *Figure 4-8 - Figure 4-11*. It clearly shows that enteric fermentation is the largest source for methane emissions within this sector, while "Agriculture soils" is the largest emitter of nitrous oxide.

Table 4-49 Methane and Nitrous Oxide emissions (in Gg) from agriculture sector in 1990-2017 years

Year	CH4				N2O												
	Enteric fermentation (3.A)	Manure management (3.B)	Field burning of Agricultural Residues (3.F)	CH4 total	Manure management – direct (3.B)	Manure management – indirect (3.B)	Agricultural soils (3.D)	Direct soil emissions (3.D.a)	Synthetic fertilizers (3.D.a.1)	Organic N fertilizers (3.D.a.2)	Urine & dung from grazing animals (3.D.a.3)	Crop residue decomposition (3.D.a.4)	Indirect soil emissions (3.D.b)	Atmospheric deposition (3.D.b.1)	Nitrogen leaching & run-off (3.D.b.2)	Field burning of Agricultural Residues (3.F)	N_2O total
1990	89.67	5.80	0.51	95.99	0.96	0.22	5.54	3.49	1.19	3.40	3.77	0.20	2.05	0.33	1.72	0.01	6.73
1991	83.28	5.05	0.44	88.77	0.88	0.20	4.87	3.07	0.98	2.92	3.23	0.17	1.80	0.30	1.50	0.01	5.96
1992	68.96	3.55	0.39	72.90	0.71	0.16	4.11	2.59	0.90	2.54	2.82	0.15	1.52	0.25	1.28	0.01	4.99
1993	63.25	3.00	0.32	66.56	0.66	0.15	3.81	2.39	0.90	0.30	1.08	0.12	1.42	0.23	1.19	0.01	4.63
1994	63.53	3.01	0.38	66.92	0.67	0.15	3.30	2.08	0.61	0.30	1.04	0.13	1.22	0.20	1.01	0.01	4.13
1995	65.16	3.01	0.38	68.54	0.69	0.15	3.56	2.24	0.76	0.31	1.06	0.12	1.32	0.22	1.11	0.01	4.41
1996	67.06	2.98	0.46	70.50	0.71	0.15	5.14	3.18	1.66	0.31	1.06	0.14	1.96	0.29	1.67	0.01	6.01
1997	68.13	3.01	0.64	71.79	0.72	0.16	5.61	3.47	1.87	0.32	1.07	0.21	2.15	0.31	1.84	0.02	6.51
1998	69.84	3.04	0.44	73.32	0.73	0.16	4.40	2.74	1.21	0.32	1.05	0.16	1.66	0.25	1.41	0.01	5.30
1999	74.78	3.33	0.57	78.67	0.79	0.17	5.18	3.21	1.56	0.34	1.13	0.19	1.97	0.29	1.67	0.02	6.16
2000	78.26	3.50	0.31	82.07	0.82	0.18	4.13	2.59	0.93	0.35	1.17	0.13	1.54	0.25	1.29	0.01	5.14
2001	78.88	3.55	0.56	82.98	0.83	0.18	4.56	2.85	1.13	0.36	1.20	0.17	1.71	0.27	1.44	0.01	5.58
2002	81.42	3.60	0.50	85.52	0.86	0.19	5.15	3.21	1.43	0.37	1.24	0.17	1.94	0.30	1.64	0.01	6.21
2003	83.37	3.76	0.56	87.68	0.88	0.19	5.34	3.33	1.49	0.38	1.27	0.18	2.02	0.31	1.71	0.02	6.43
2004	79.96	3.76	0.51	84.23	0.84	0.18	4.34	2.73	0.94	0.37	1.26	0.16	1.61	0.26	1.35	0.01	5.37
2005	80.89	3.61	0.53	85.03	0.85	0.19	4.36	2.74	0.91	0.37	1.26	0.21	1.62	0.26	1.36	0.01	5.41
2006	73.40	2.95	0.24	76.60	0.76	0.17	4.62	2.88	1.32	0.33	1.13	0.10	1.74	0.27	1.47	0.01	5.56
2007	71.24	1.99	0.31	73.54	0.72	0.15	3.88	2.43	0.92	0.31	1.09	0.11	1.45	0.23	1.21	0.01	4.76
2008	73.14	1.94	0.33	75.41	0.74	0.16	4.08	2.56	1.01	0.31	1.11	0.12	1.53	0.24	1.28	0.01	4.99
2009	69.45	2.06	0.27	71.78	0.71	0.15	4.15	2.59	1.13	0.30	1.05	0.10	1.56	0.24	1.32	0.01	5.02
2010	72.32	2.01	0.18	74.51	0.74	0.16	3.90	2.44	0.99	0.31	1.07	0.07	1.46	0.24	1.22	0.01	4.81
2011	71.61	1.96	0.30	73.87	0.73	0.16	3.71	2.33	0.85	0.31	1.06	0.11	1.38	0.22	1.16	0.01	4.61
2012	76.24	2.44	0.28	78.95	0.79	0.17	4.09	2.56	0.97	0.33	1.15	0.11	1.52	0.25	1.28	0.01	5.06
2013	81.54	2.50	0.35	84.38	0.84	0.18	4.81	3.00	1.27	0.36	1.24	0.13	1.80	0.28	1.52	0.01	5.84
2014	87.69	2.50	0.26	90.46	0.91	0.19	4.48	2.82	1.00	0.38	1.32	0.11	1.67	0.27	1.39	0.01	5.59
2015	91.08	2.56	0.27	93.91	0.94	0.20	4.57	2.87	0.98	0.40	1.37	0.12	1.69	0.28	1.42	0.01	5.72
2016	92.47	2.48	0.32	95.27	0.96	0.20	4.63	2.91	1.00	0.40	1.39	0.12	1.72	0.28	1.43	0.01	5.80
2017	87.12	2.43	0.23	89.78	0.90	0.19	4.07	2.57	0.78	0.38	1.32	0.09	1.50	0.26	1.24	0.01	5.17

Table 4-50 GHG emissions (in Gg CO_2-eq) from agriculture sector in1990 -2017 years

Year	CH_4				N_2O													
	Enteric fermentation (3.A)	Manure management (3.B)	Field burning of Agricultural Residues (3.F)	CH_4 total	Manure management – direct (3.B)	Manure management – Indirect (3.B)	Agricultural soils (3.D)	Direct soil emissions (3.D.a)	Synthetic fertilizers (3.D.a.1)	Organic N fertilizers (3.D.a.2)	Urine & dung from grazing animals (3.D.a.3)	Crop residue decomposition (3.D.a.4)	Indirect soil emissions (3.D.b)	Atmospheric deposition (3.D.b.1)	Nitrogen leaching & run-off (3.D.b.2)	Field burning of Agricultural Residues (3.F)	N_2O total	Total Agriculture sector
1990	1,883	122	11	2,016	297	68	1,717	1,080	370	140	508	62	637	103	534	4	2,086	4,102
1991	1,749	106	9	1,864	274	62	1,509	952	303	129	467	52	557	92	466	4	1,849	3,713
1992	1,448	75	8	1,531	221	50	1,274	801	279	102	375	45	473	76	396	3	1,548	3,079
1993	1,328	63	7	1,398	204	45	1,181	741	278	92	335	36	440	71	369	3	1,433	2,831
1994	1,334	63	8	1,405	207	46	1,022	645	189	93	324	40	377	62	314	3	1,278	2,683
1995	1,368	63	8	1,439	213	47	1,103	694	235	95	327	36	409	67	343	3	1,366	2,805
1996	1,408	63	10	1,480	220	48	1,592	985	513	97	330	45	607	90	517	4	1,864	3,344
1997	1,431	63	14	1,508	224	49	1,740	1,075	580	99	330	66	666	95	571	5	2,018	3,526
1998	1,467	64	9	1,540	227	49	1,364	850	376	98	327	49	515	78	436	4	1,644	3,184
1999	1,570	70	12	1,652	244	53	1,606	997	482	105	351	58	609	90	519	5	1,908	3,560
2000	1,643	74	7	1,723	256	56	1,279	803	289	109	363	41	477	77	400	3	1,594	3,317
2001	1,656	74	12	1,743	257	56	1,413	884	349	111	371	54	530	83	447	5	1,731	3,474
2002	1,710	76	11	1,796	265	58	1,596	994	443	114	385	51	602	92	510	4	1,923	3,719

Year	CH_4				N_2O													Total Agriculture sector
	Enteric fermentation (3.A)	Manure management (3.B)	Field burning of Agricultural Residues (3.F)	CH_4 total	Manure management – direct (3.B)	Manure management – Indirect (3.B)	Agricultural soils (3.D)	Direct soil emissions (3.D.a)	Synthetic fertilizers (3.D.a.1)	Organic N fertilizers (3.D.a.2)	Urine & dung from grazing animals (3.D.a.3)	Crop residue decomposition (3.D.a.4)	Indirect soil emissions (3.D.b)	Atmospheric deposition (3.D.b.1)	Nitrogen leaching & run-off (3.D.b.2)	Field burning of Agricultural Residues (3.F)	N_2O total	
2003	1,751	79	12	1,841	272	59	1,656	1,031	462	117	395	57	625	95	530	5	1,992	3,833
2004	1,679	79	11	1,769	260	57	1,346	846	290	114	392	50	500	81	420	4	1,667	3,436
2005	1,699	76	11	1,786	262	57	1,351	849	281	113	390	65	502	80	422	5	1,675	3,461
2006	1,541	62	5	1,609	235	51	1,432	892	409	101	351	30	540	84	456	2	1,720	3,329
2007	1,496	42	6	1,544	224	48	1,203	755	285	95	339	35	448	72	376	3	1,478	3,022
2008	1,536	41	7	1,584	230	49	1,266	793	312	97	345	38	473	75	398	3	1,548	3,132
2009	1,459	43	6	1,507	220	47	1,285	802	351	93	326	31	483	76	408	2	1,554	3,061
2010	1,519	42	4	1,565	229	49	1,210	757	306	97	333	22	453	73	379	2	1,490	3,055
2011	1,504	41	6	1,551	228	48	1,151	722	264	96	328	34	429	69	359	3	1,430	2,981
2012	1,601	51	6	1,658	244	52	1,267	794	301	104	356	33	473	76	396	2	1,565	3,223
2013	1,712	52	7	1,772	261	56	1,490	931	393	111	385	41	560	88	472	3	1,810	3,582
2014	1,842	53	6	1,900	281	60	1,390	874	309	119	410	35	517	85	432	2	1,733	3,633
2015	1,913	54	6	1,972	293	62	1,416	891	304	124	425	38	525	87	439	2	1,773	3,745
2016	1,942	52	7	2,001	297	63	1,434	902	311	125	430	36	532	88	444	3	1,797	3,798
2017	1,830	51	5	1,885	280	60	1,261	796	242	119	408	27	465	79	386	2	1,603	3,488

Figure 4-8 Methane emissions in 1990-2017 years

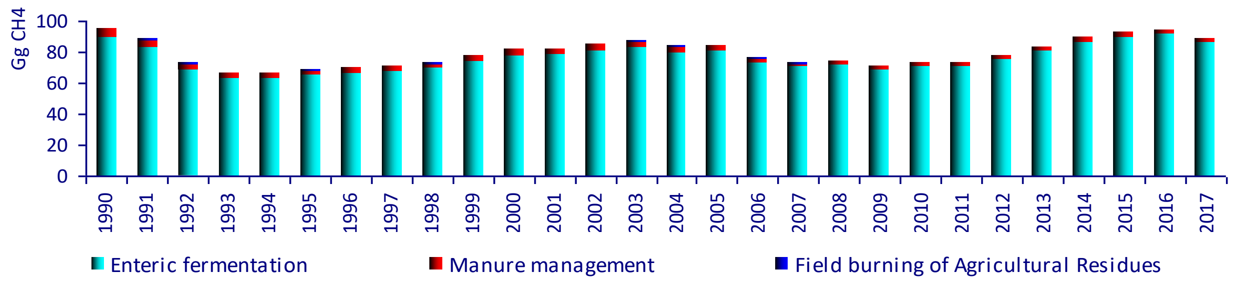


Figure 4-9 Nitrous Oxide emissions in 1990-2017 years

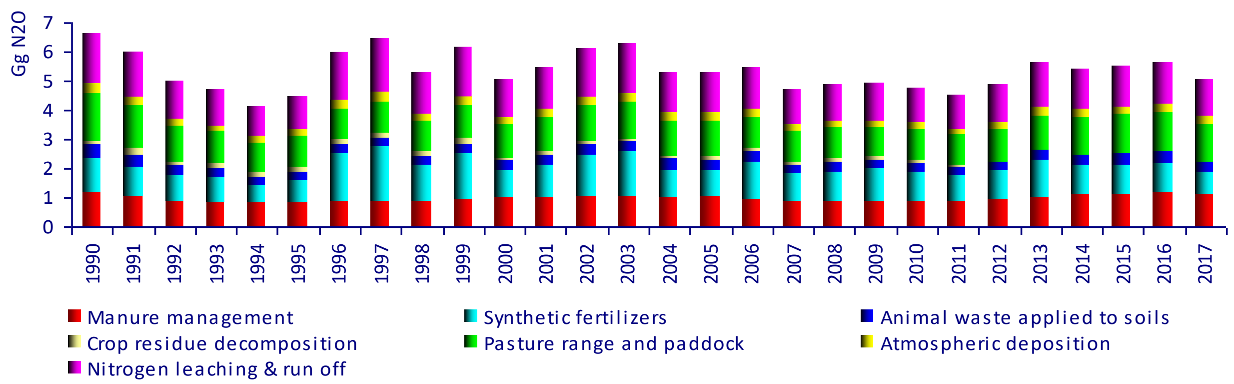


Figure 4-10 GHG emissions from Agriculture sector by sources in 1990-2017 years

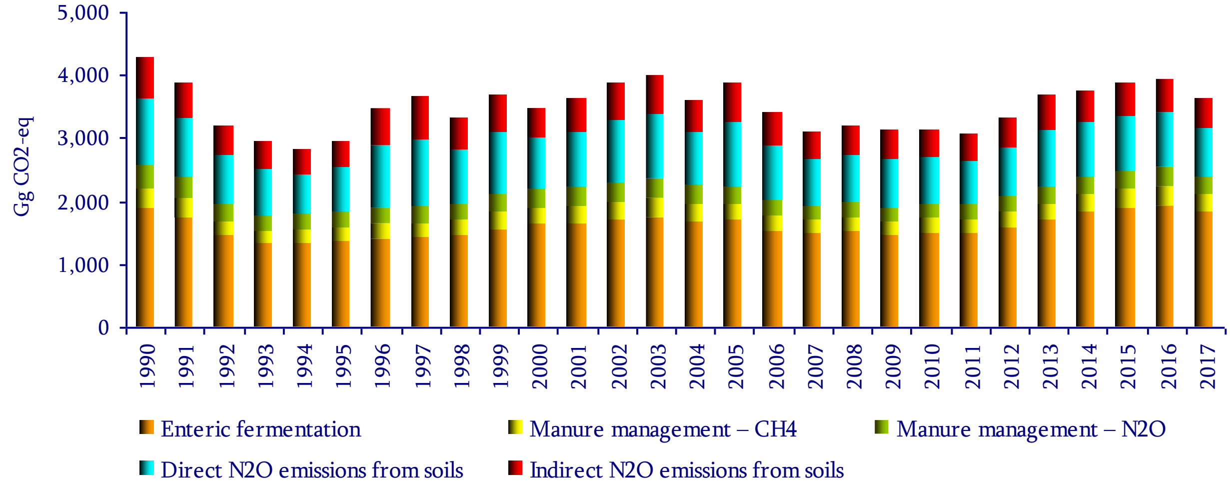
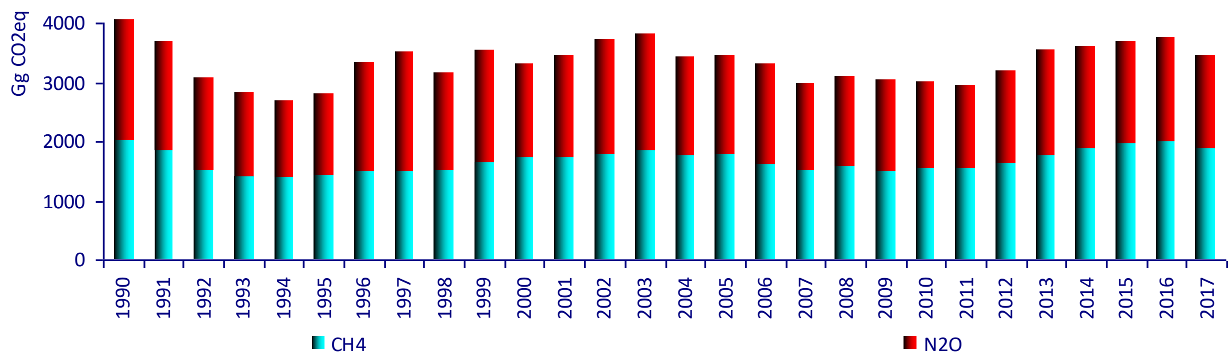


Figure 4-11 GHG emissions by gases in 1990-2017 years



The shares of gases in agriculture sector emissions as well as share of sub-categories emissions in agriculture sector emissions are presented in *Table 4-51.* According to this table share of methane varies within 43–54 percent. Enteric fermentation is the largest source for emission. s. The share of nitrous oxide varies within 46-57 percent.

Table 4-51 Share of sub-categories emissions in agriculture sector emissions (in %)

	CH_4				N_2O													
Year	**Enteric fermentation (3.A)**	**Manure management (3.B)**	**Field burning of Agricultural Residues (3.F)**	**CH_4 total**	**Manure management (3.B)**	**Agricultural soils (3.D)**	**Direct soil emissions (3.D.a)**	**Synthetic fertilizers (3.D.a.1)**	**Organic N fertilizers (3.D.a.2)**	**Urine & dung from grazing animals (3.D.a.3)**	**Crop residue decomposition (3.D.a.4)**	**Indirect soil emissions (3.D.b)**	**Atmospheric deposition (3.D.b.1)**	**Nitrogen leaching & run-off (3.D.b.2)**	**Field burning of Agricultural Residues (3.F)**	**N_2O total**	**Total Agriculture sector**
1990	46	3	0.3	**49**	9	42	26	9	3	2	12	16	3	13	0.1	**51**	**100**
1991	47	3	0.3	**50**	9	41	26	8	3	1	13	15	2	13	0.1	**50**	**100**
1992	47	2	0.3	**50**	9	41	26	9	3	1	12	15	2	13	0.1	**50**	**100**
1993	47	2	0.3	**49**	9	42	26	10	3	1	12	16	2	13	0.1	**51**	**100**
1994	50	2	0.3	**52**	9	38	24	7	3	1	12	14	2	12	0.1	**48**	**100**
1995	49	2	0.3	**51**	9	39	25	8	3	1	12	15	2	12	0.1	**49**	**100**

Year	CH_4				N_2O												Total Agriculture sector
	Enteric fermentation (3.A)	Manure management (3.B)	Field burning of Agricultural Residues (3.F)	CH_4 total	Manure management (3.B)	Agricultural soils (3.D)	Direct soil emissions (3.D.a)	Synthetic fertilizers (3.D.a.1)	Organic N fertilizers (3.D.a.2)	Urine & dung from grazing animals (3.D.a.3)	Crop residue decomposition (3.D.a.4)	Indirect soil emissions (3.D.b)	Atmospheric deposition (3.D.b.1)	Nitrogen leaching & run-off (3.D.b.2)	Field burning of Agricultural Residues (3.F)	N_2O total	
1996	42	2	0.2	**44**	8	48	29	15	3	1	10	18	3	15	0.1	**56**	**100**
1997	41	2	0.2	**43**	8	49	31	16	3	2	9	19	3	16	0.1	**57**	**100**
1998	46	2	0.2	**48**	9	43	27	12	3	2	10	16	2	14	0.1	**52**	**100**
1999	44	2	0.2	**46**	8	45	28	14	3	2	10	17	3	15	0.1	**54**	**100**
2000	50	2	0.2	**52**	9	39	24	9	3	1	11	14	2	12	0.1	**48**	**100**
2001	48	2	0.3	**50**	9	41	25	10	3	2	11	15	2	13	0.1	**50**	**100**
2002	46	2	0.2	**48**	9	43	27	12	3	1	10	16	2	14	0.1	**52**	**100**
2003	46	2	0.2	**48**	9	43	27	12	3	1	10	16	2	14	0.1	**52**	**100**
2004	49	2	0.2	**51**	9	39	25	8	3	1	11	15	2	12	0.1	**49**	**100**
2005	49	2	0.3	**52**	9	39	25	8	3	2	11	14	2	12	0.1	**48**	**100**
2006	46	2	0.3	**48**	9	43	27	12	3	1	11	16	3	14	0.1	**52**	**100**
2007	50	1	0.2	**51**	9	40	25	9	3	1	11	15	2	12	0.1	**49**	**100**
2008	49	1	0.2	**51**	9	40	25	10	3	1	11	15	2	13	0.1	**49**	**100**
2009	48	1	0.2	**49**	9	42	26	11	3	1	11	16	2	13	0.1	**51**	**100**
2010	50	1	0.1	**51**	9	40	25	10	3	1	11	15	2	12	0.1	**49**	**100**
2011	50	1	0.2	**52**	9	39	24	9	3	1	11	14	2	12	0.1	**48**	**100**
2012	50	2	0.2	**51**	9	39	25	9	3	1	11	15	2	12	0.1	**49**	**100**
2013	48	1	0.2	**49**	9	42	26	11	3	1	11	16	2	13	0.1	**51**	**100**
2014	51	1	0.2	**52**	9	38	24	9	3	1	11	14	2	12	0.1	**48**	**100**
2015	51	1	0.2	**53**	9	38	24	8	3	1	11	14	2	12	0.1	**47**	**100**
2016	51	1	0.2	**53**	9	38	24	8	3	1	11	14	2	12	0.1	**47**	**100**
2017	52	1	0.1	**54**	10	36	23	7	3	1	12	13	2	11	0.1	**46**	**100**

Comparison of recalculated GHG emissions with relevant values from SBUR

For years 1990, 1994, 2000, 2005, 2011-2015 the recalculated values have been compared with relevant values from Second Biennial Update Report (SBUR). Differences are provided in *Table 4-52*. According to this table the difference between FNC and SBUR varies within 5%-15%. Enteric fermentation and manure management bear the largest difference among the categories. As mentioned above, compared to the previous inventory, specified data on cattle distribution by breeds are used. Besides, tier 2 approach for methane emissions from manure management was applied.

Table 4-52 Difference (in %) between FNC and Second BUR

Year	CH_4				N_2O												Total Agriculture total
	Enteric fermentation	Manure management	Field burning of Agricultural Residues	CH_4 total	Manure management	Agricultural soils	Direct soil emissions	Synthetic fertilizers	Animal waste applied to soils	Crop residue decomposition	Pasture range and paddock	Indirect emissions	Atmospheric deposition	Nitrogen leaching & run off	Field burning of Agricultural Residues	N_2O total	
1990	16	-36	-	16	-3	-1	-1	0	-3	0	-2	-1	-2	-1	-	0	**5**
1994	23	-42	-	23	1	1	1	0	2	-1	1	0	1	0	-	2	**10**
2000	24	-44	-	24	2	1	1	0	2	-1	2	1	1	1	-	2	**10**
2005	25	-43	-	25	3	2	1	0	3	0	2	2	2	1	-	4	**11**
2010	28	-55	-	28	5	4	4	0	5	-1	7	3	5	3	-	4	**13**
2011	27	-56	-	27	4	4	4	0	4	11	7	4	3	4	-	5	**13**

Year	CH_4				N_2O												Total Agriculture total
	Enteric fermentation	Manure management	Field burning of Agricultural Residues	CH_4 total	Manure management	Agricultural soils	Direct soil emissions	Synthetic fertilizers	Animal waste applied to soils	Crop residue decomposition	Pasture range and paddock	Indirect emissions	Atmospheric deposition	Nitrogen leaching & run off	Field burning of Agricultural Residues	N_2O total	
2012	28	-52	-	28	5	4	4	0	5	17	7	4	5	4	-	5	**13**
2013	28	-52	-	28	6	4	4	0	6	0	7	3	4	3	-	5	**13**
2014	29	-54	-	29	6	4	4	0	6	1	8	4	5	4	-	5	**14**
2015	30	-54	-	30	7	5	5	0	7	0	9	4	6	4	-	6	**15**

4.11. Enteric Fermentation (3.A.)

The emissions source category "enteric fermentation" consists of the following sub-sources: cattle, buffalos, sheep, goats (multi-chamber stomachs), horses, asses, and swine (monogastric stomachs). Camels and mules are not relevant for Georgia. For 1900-2017 years period GHG emissions mainly varied according to the livestock population.

Methane emissions in Gg from enteric fermentation in livestock are presented in *Table 4-53***.** Major "Key source" is enteric fermentation by cattle, which contributes about 90% of the total emissions from enteric fermentation. Data on number of asses for several years are absent.

Table 4-53 Methane emissions (in Gg) from enteric fermentation in livestock

Year	Cattle 3.A.1	Buffalos 3.A.2	Sheep 3.A.3	Goats 3.A.4	Horses 3.A.5.1	Asses 3.A.5.2	Swine 3.A.6	Total in Gg CH4	Total in Gg CO_2eq
1990	78.32	2.02	7.75	0.34	0.35	NE	0.88	**89.67**	**1,883**
1991	73.07	1.81	7.06	0.29	0.33	NE	0.73	**83.28**	**1,749**
1992	60.57	1.65	5.73	0.23	0.3	NE	0.48	**68.96**	**1,448**
1993	56.4	1.35	4.6	0.19	0.35	NE	0.37	**63.25**	**1,328**
1994	57.59	1.22	3.77	0.2	0.39	NE	0.37	**63.53**	**1,334**
1995	59.53	1.22	3.37	0.25	0.43	NE	0.35	**65.16**	**1,368**
1996	61.76	1.23	3	0.26	0.47	NE	0.33	**67.06**	**1,408**
1997	63.04	1.25	2.62	0.3	0.5	0.09	0.33	**68.13**	**1,431**
1998	64.63	1.25	2.61	0.33	0.55	0.11	0.37	**69.84**	**1,467**
1999	69.21	1.25	2.77	0.4	0.61	0.12	0.41	**74.78**	**1,570**
2000	72.74	1.31	2.73	0.4	0.63	NE	0.44	**78.26**	**1,643**
2001	72.99	1.34	2.84	0.46	0.69	0.11	0.45	**78.88**	**1,656**
2002	75.39	1.32	3.06	0.44	0.77	NE	0.45	**81.42**	**1,710**
2003	77.18	1.33	3.14	0.47	0.78	NE	0.47	**83.37**	**1,751**
2004	73.2	1.32	3.45	0.58	0.8	0.13	0.48	**79.96**	**1,679**
2005	74.23	1.23	3.6	0.48	0.77	0.13	0.46	**80.89**	**1,699**
2006	67.35	1.21	3.48	0.46	0.47	0.08	0.34	**73.4**	**1,541**
2007	65.58	1.07	3.56	0.43	0.41	0.09	0.11	**71.24**	**1,496**
2008	67.61	1.01	3.45	0.4	0.5	0.08	0.09	**73.14**	**1,536**
2009	64.38	0.98	3.01	0.36	0.52	0.07	0.14	**69.45**	**1,459**
2010	67.35	0.93	2.98	0.29	0.55	0.11	0.11	**72.32**	**1,519**
2011	66.81	0.93	2.88	0.27	0.53	0.08	0.11	**71.61**	**1,504**
2012	70.77	0.94	3.44	0.27	0.55	0.06	0.2	**76.24**	**1,601**
2013	75.43	1	3.98	0.3	0.55	0.08	0.19	**81.54**	**1,712**
2014	81.7	0.65	4.33	0.27	0.51	0.07	0.17	**87.69**	**1,842**
2015	84.96	0.85	4.21	0.25	0.61	0.04	0.16	**91.08**	**1,913**

Year	Cattle 3.A.1	Buffalos 3.A.2	Sheep 3.A.3	Goats 3.A.4	Horses 3.A.5.1	Asses 3.A.5.2	Swine 3.A.6	Total in Gg CH4	Total in Gg CO_2eq
2016	86.28	0.92	4.38	0.3	0.41	0.04	0.14	**92.47**	**1,942**
2017	81.21	0.8	4.28	0.26	0.4	0.03	0.15	**87.12**	**1,830**

4.11.1. Cattle (3.A.1.)

Georgian Mountain and Red Mingrelian are native cattle breeds prevailing in Georgia. Georgian Mountain and Red Mingrelian are late maturing breeds, characterized by small weight, low productivity, and high fattiness of milk. Since the 30-ies of the 20th century several high-productive early maturing breeds have been imported. According to estimations, the characteristics and accordingly the emission factors of early maturing breeds are slightly (by 3-4%) different. Therefore, averaged value of emission factors has been applied and 3 breeds have been considered: Early maturing, Georgian Mountain and Red Mingrelian. Specified data on cattle distribution by breeds are provided by Head of the Department of Zootechny of the Agrarian University of Georgia Mr. Levan Tortladze.

Table 4-54 Cattle distribution by breeds

Year	Breed						Total number
	Early maturing		Georgian Mountain		Red Mingrelian		
	%	Number	%	Number	%	Number	
1990	60.2	806,576	23.8	318,879	16.0	214,372	1,339,828
1991	60.5	755,266	23.6	295,080	15.8	197,615	1,247,961
1992	60.8	628,438	23.5	242,636	15.7	161,861	1,032,935
1993	61.2	587,289	23.3	224,075	15.5	148,887	960,251
1994	61.5	601,940	23.2	226,951	15.3	150,191	979,083
1995	61.8	624,476	23.0	232,663	15.2	153,340	1,010,479
1996	62.1	650,242	22.9	239,392	15.0	157,117	1,046,752
1997	62.4	666,105	22.7	242,322	14.8	158,365	1,066,792
1998	62.8	685,340	22.6	246,356	14.7	160,306	1,092,002
1999	63.1	736,507	22.4	261,595	14.5	169,474	1,167,576
2000	63.4	776,787	22.3	272,610	14.4	175,818	1,225,216
2001	63.7	782,173	22.1	271,220	14.2	174,123	1,227,516
2002	64.0	810,779	21.9	277,771	14.0	177,500	1,266,051
2003	64.4	832,828	21.8	281,901	13.9	179,286	1,294,015
2004	64.7	792,621	21.6	265,065	13.7	167,764	1,225,451
2005	65.0	806,547	21.5	266,471	13.5	167,824	1,240,841
2006	65.3	734,208	21.3	239,641	13.4	150,169	1,124,017
2007	65.6	717,400	21.2	231,319	13.2	144,212	1,092,931
2008	66.0	742,032	21.0	236,357	13.0	146,584	1,124,972
2009	66.3	708,967	20.9	223,077	12.9	137,611	1,069,655
2010	66.6	744,115	20.7	231,279	12.7	141,896	1,117,289
2011	68.0	748,949	20.1	221,264	11.9	130,967	1,101,180
2012	69.4	804,547	19.5	225,820	11.1	128,477	1,158,844
2013	70.8	869,385	18.9	231,705	10.3	126,161	1,227,252
2014	72.3	954,302	18.3	241,349	9.5	125,121	1,320,772
2015	73.7	1,005,441	17.7	241,124	8.7	118,287	1,364,852
2016	73.7	1,021,077	17.7	244,874	8.7	120,127	1,386,077
2017	73.7	961,055	17.7	230,479	8.7	113,065	1,304,600

According to IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (further referred to as IPCC GPG), in case enteric fermentation is a key source category for the animal categories that represent a large portion of the country’s total emissions the Tier 2 approach should be used. For 1990-2015 years period methane emissions from cattle constituted about 90% of the total methane emissions from “Enteric fermentation”. Consequently, for this category tier 2 approach is used.

Methodology:

Tier 2 represents more complicated approach, which requires detailed characteristics of cattle (breed, age, weight, milk yield, birth etc.). Emission factor for each selected animal category (type) was assessed based on these data. Afterwards, emissions were calculated for each group of cattle by multiplying a population of cattle (grouping is made according to breed and age) by corresponding emission factor and summing up calculated emissions.

Activity data:

Methane emissions from enteric fermentation in cattle depends on cattle characteristics. Cattle has been classified by age based on the scientific information obtained from zoological veterinary experts. The classification has been performed separately for early maturing and late maturing breeds as their growth characteristics are different.

Table 4-55 presents Georgian Mountain cattle distribution by age.

Table 5-8 presents Red Mingrelian cattle distribution by age

Table 4-57 presents early maturing cattle distribution by age

Table 4-55 Georgian Mountain cattle distribution by age

	Population, thousand heads																	
Cattle category	**Calf – females**	**Heifer**	**Heifer**	**Heifer**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Calf – males**	**Bullock**	**Bullock**	**Bullock**	**Bull (castrate)**	**Bull (castrate)**	**Bull (castrate)**	**Total**
Age, year	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**4-5**	**5-6**	**5-6**	**>6**	**>6**	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**>6**	
1990	35.6	27.6	24.6	24.1	10.4	11.2	9.8	10.6	83.3	41.0	11.0	9.6	7.7	6.4	2.6	2.1	1.3	318.9
1991	32.9	25.5	22.8	22.3	9.6	10.4	9.1	9.8	77.1	38.0	10.2	8.9	7.2	5.9	2.4	2.0	1.2	295.1
1992	27.1	21.0	18.7	18.3	7.9	8.5	7.4	8.0	63.4	31.2	8.3	7.3	5.9	4.9	2.0	1.6	1.0	242.6
1993	25.0	19.4	17.3	16.9	7.3	7.9	6.9	7.4	58.5	28.8	7.7	6.8	5.4	4.5	1.9	1.5	0.9	224.1
1994	25.3	19.6	17.5	17.1	7.4	8.0	7.0	7.5	59.3	29.2	7.8	6.9	5.5	4.6	1.9	1.5	0.9	227.0
1995	25.9	20.1	17.9	17.6	7.6	8.2	7.1	7.7	60.8	29.9	8.0	7.0	5.6	4.7	1.9	1.5	1.0	232.7
1996	26.7	20.7	18.5	18.1	7.8	8.4	7.3	7.9	62.5	30.8	8.2	7.2	5.8	4.8	2.0	1.6	1.0	239.4
1997	27.0	20.9	18.7	18.3	7.9	8.5	7.4	8.0	63.3	31.2	8.3	7.3	5.9	4.9	2.0	1.6	1.0	242.3
1998	27.5	21.3	19.0	18.6	8.0	8.7	7.6	8.2	64.3	31.7	8.5	7.5	6.0	5.0	2.0	1.6	1.0	246.4
1999	29.2	22.6	20.2	19.7	8.5	9.2	8.0	8.7	68.3	33.7	9.0	7.9	6.3	5.3	2.2	1.7	1.1	261.6
2000	30.4	23.6	21.0	20.6	8.9	9.6	8.4	9.0	71.2	35.1	9.4	8.2	6.6	5.5	2.3	1.8	1.1	272.6
2001	30.2	23.4	20.9	20.5	8.8	9.6	8.3	9.0	70.8	34.9	9.3	8.2	6.6	5.5	2.2	1.8	1.1	271.2
2002	31.0	24.0	21.4	21.0	9.0	9.8	8.5	9.2	72.5	35.8	9.6	8.4	6.7	5.6	2.3	1.8	1.2	277.8
2003	31.4	24.4	21.7	21.3	9.2	9.9	8.6	9.3	73.6	36.3	9.7	8.5	6.8	5.7	2.3	1.9	1.2	281.9
2004	29.6	22.9	20.4	20.0	8.6	9.3	8.1	8.8	69.2	34.1	9.1	8.0	6.4	5.3	2.2	1.8	1.1	265.1
2005	29.7	23.0	20.5	20.1	8.7	9.4	8.2	8.8	69.6	34.3	9.2	8.1	6.5	5.4	2.2	1.8	1.1	266.5
2006	26.7	20.7	18.5	18.1	7.8	8.4	7.4	7.9	62.6	30.8	8.2	7.3	5.8	4.8	2.0	1.6	1.0	239.6
2007	25.8	20.0	17.8	17.5	7.5	8.2	7.1	7.7	60.4	29.8	8.0	7.0	5.6	4.7	1.9	1.5	1.0	231.3
2008	26.4	20.4	18.2	17.8	7.7	8.3	7.2	7.8	61.7	30.4	8.1	7.2	5.7	4.8	2.0	1.6	1.0	236.4
2009	24.9	19.3	17.2	16.8	7.3	7.9	6.8	7.4	58.3	28.7	7.7	6.8	5.4	4.5	1.8	1.5	0.9	223.1

	Population, thousand heads																	
Cattle category	**Calf – females**	**Heifer**	**Heifer**	**Heifer**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Calf – males**	**Bullock**	**Bullock**	**Bullock**	**Bull (castrate)**	**Bull (castrate)**	**Bull (castrate)**	**Total**
Age, year	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**4-5**	**5-6**	**5-6**	**>6**	**>6**	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**>6**	
2010	25.8	20.0	17.8	17.4	7.5	8.1	7.1	7.7	60.4	29.8	8.0	7.0	5.6	4.6	1.9	1.5	1.0	231.3
2011	24.7	19.1	17.1	16.7	7.2	7.8	6.8	7.3	57.8	28.5	7.6	6.7	5.4	4.4	1.8	1.5	0.9	221.3
2012	25.2	19.5	17.4	17.0	7.3	8.0	6.9	7.5	59.0	29.1	7.8	6.8	5.5	4.5	1.9	1.5	0.9	225.8
2013	25.8	20.0	17.9	17.5	7.5	8.2	7.1	7.7	60.5	29.8	8.0	7.0	5.6	4.7	1.9	1.5	1.0	231.7
2014	26.9	20.9	18.6	18.2	7.9	8.5	7.4	8.0	63.0	31.1	8.3	7.3	5.9	4.9	2.0	1.6	1.0	241.3
2015	26.9	20.8	18.6	18.2	7.8	8.5	7.4	8.0	63.0	31.0	8.3	7.3	5.8	4.8	2.0	1.6	1.0	241.1
2016	27.3	21.2	18.9	18.5	8.0	8.6	7.5	8.1	63.9	31.5	8.4	7.4	5.9	4.9	2.0	1.6	1.0	244.9
2017	25.7	19.9	17.8	17.4	7.5	8.1	7.1	7.6	60.2	29.7	7.9	7.0	5.6	4.6	1.9	1.5	1.0	230.5

Table 4-56 Red Mingrelian cattle distribution by age

	Population, thousand heads																	
Cattle category	**Calf – females**	**Heifer**	**Heifer**	**Heifer**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Calf – males**	**Bullock**	**Bullock**	**Bullock**	**Bull (castrate)**	**Bull (castrate)**	**Bull (castrate)**	**Total**
Age, year	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**4-5**	**5-6**	**5-6**	**>6**	**>6**	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**>6**	
1990	23.9	18.5	16.5	16.2	7.0	7.6	6.6	7.1	56.0	27.6	7.4	6.5	5.2	4.3	1.8	1.4	0.9	214.4
1991	22.0	17.1	15.2	14.9	6.4	7.0	6.1	6.6	51.6	25.4	6.8	6.0	4.8	4.0	1.6	1.3	0.8	197.6
1992	18.0	14.0	12.5	12.2	5.3	5.7	5.0	5.4	42.3	20.8	5.6	4.9	3.9	3.3	1.3	1.1	0.7	161.9
1993	16.6	12.9	11.5	11.2	4.8	5.2	4.6	4.9	38.9	19.2	5.1	4.5	3.6	3.0	1.2	1.0	0.6	148.9
1994	16.7	13.0	11.6	11.3	4.9	5.3	4.6	5.0	39.2	19.3	5.2	4.5	3.6	3.0	1.2	1.0	0.6	150.2
1995	17.1	13.3	11.8	11.6	5.0	5.4	4.7	5.1	40.0	19.7	5.3	4.6	3.7	3.1	1.3	1.0	0.6	153.3
1996	17.5	13.6	12.1	11.9	5.1	5.5	4.8	5.2	41.0	20.2	5.4	4.8	3.8	3.2	1.3	1.0	0.7	157.1
1997	17.7	13.7	12.2	11.9	5.2	5.6	4.9	5.3	41.4	20.4	5.4	4.8	3.8	3.2	1.3	1.1	0.7	158.4
1998	17.9	13.9	12.4	12.1	5.2	5.6	4.9	5.3	41.9	20.6	5.5	4.9	3.9	3.2	1.3	1.1	0.7	160.3
1999	18.9	14.6	13.1	12.8	5.5	6.0	5.2	5.6	44.3	21.8	5.8	5.1	4.1	3.4	1.4	1.1	0.7	169.5
2000	19.6	15.2	13.6	13.3	5.7	6.2	5.4	5.8	45.9	22.6	6.0	5.3	4.3	3.5	1.5	1.2	0.7	175.8
2001	19.4	15.0	13.4	13.1	5.7	6.1	5.3	5.8	45.5	22.4	6.0	5.3	4.2	3.5	1.4	1.2	0.7	174.1
2002	19.8	15.3	13.7	13.4	5.8	6.3	5.4	5.9	46.4	22.8	6.1	5.4	4.3	3.6	1.5	1.2	0.7	177.5
2003	20.0	15.5	13.8	13.5	5.8	6.3	5.5	5.9	46.8	23.1	6.2	5.4	4.3	3.6	1.5	1.2	0.7	179.3
2004	18.7	14.5	12.9	12.7	5.5	5.9	5.1	5.6	43.8	21.6	5.8	5.1	4.1	3.4	1.4	1.1	0.7	167.8
2005	18.7	14.5	12.9	12.7	5.5	5.9	5.1	5.6	43.8	21.6	5.8	5.1	4.1	3.4	1.4	1.1	0.7	167.8
2006	16.7	13.0	11.6	11.3	4.9	5.3	4.6	5.0	39.2	19.3	5.2	4.5	3.6	3.0	1.2	1.0	0.6	150.2
2007	16.1	12.5	11.1	10.9	4.7	5.1	4.4	4.8	37.7	18.6	5.0	4.4	3.5	2.9	1.2	1.0	0.6	144.2
2008	16.3	12.7	11.3	11.1	4.8	5.2	4.5	4.9	38.3	18.9	5.0	4.4	3.6	2.9	1.2	1.0	0.6	146.6
2009	15.3	11.9	10.6	10.4	4.5	4.8	4.2	4.6	35.9	17.7	4.7	4.2	3.3	2.8	1.1	0.9	0.6	137.6
2010	15.8	12.3	10.9	10.7	4.6	5.0	4.4	4.7	37.1	18.3	4.9	4.3	3.4	2.9	1.2	0.9	0.6	141.9
2011	14.6	11.3	10.1	9.9	4.3	4.6	4.0	4.3	34.2	16.9	4.5	4.0	3.2	2.6	1.1	0.9	0.5	131.0
2012	14.3	11.1	9.9	9.7	4.2	4.5	3.9	4.3	33.6	16.5	4.4	3.9	3.1	2.6	1.1	0.9	0.5	128.5
2013	14.1	10.9	9.7	9.5	4.1	4.4	3.9	4.2	32.9	16.2	4.3	3.8	3.1	2.5	1.0	0.8	0.5	126.2
2014	14.0	10.8	9.6	9.4	4.1	4.4	3.8	4.1	32.7	16.1	4.3	3.8	3.0	2.5	1.0	0.8	0.5	125.1
2015	13.2	10.2	9.1	8.9	3.8	4.2	3.6	3.9	30.9	15.2	4.1	3.6	2.9	2.4	1.0	0.8	0.5	118.3
2016	13.4	10.4	9.3	9.1	3.9	4.2	3.7	4.0	31.4	15.5	4.1	3.6	2.9	2.4	1.0	0.8	0.5	120.1
2017	12.6	9.8	8.7	8.5	3.7	4.0	3.5	3.7	29.5	14.6	3.9	3.4	2.7	2.3	0.9	0.7	0.5	113.1

Table 4-57 Early maturing cattle distribution by age

	Population, thousand heads															
Cattle category	**Calf – females**	**Heifer**	**Heifer**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Calf – males**	**Bullock**	**Bullock**	**Bull (castrate)**	**Bull (castrate)**	**Bull (castrate)**	**Total**
Age, year	**0-1**	**1-2**	**2-3**	**3-4**	**3-4**	**4-5**	**4-5**	**>5**	**>5**	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**>5**	
1990	109.0	95.3	86.6	34.1	36.8	36.1	39.1	183.8	90.6	35.1	24.4	18.4	8.7	4.7	4.0	806.6
1991	102.0	89.2	81.1	31.9	34.4	33.8	36.6	172.1	84.8	32.9	22.8	17.2	8.1	4.4	3.8	755.3
1992	84.9	74.2	67.5	26.6	28.6	28.1	30.5	143.2	70.6	27.3	19.0	14.3	6.8	3.6	3.1	628.4
1993	79.3	69.4	63.0	24.8	26.8	26.3	28.5	133.9	66.0	25.6	17.8	13.4	6.3	3.4	2.9	587.3
1994	81.3	71.1	64.6	25.4	27.4	26.9	29.2	137.2	67.6	26.2	18.2	13.7	6.5	3.5	3.0	601.9
1995	84.4	73.8	67.0	26.4	28.5	28.0	30.3	142.3	70.1	27.2	18.9	14.2	6.7	3.6	3.1	624.5
1996	87.8	76.8	69.8	27.5	29.6	29.1	31.5	148.2	73.0	28.3	19.7	14.8	7.0	3.8	3.2	650.2
1997	90.0	78.7	71.5	28.2	30.4	29.8	32.3	151.8	74.8	29.0	20.2	15.2	7.2	3.9	3.3	666.1
1998	92.6	80.9	73.6	29.0	31.2	30.7	33.2	156.2	77.0	29.8	20.7	15.6	7.4	4.0	3.4	685.3
1999	99.5	87.0	79.1	31.1	33.6	33.0	35.7	167.9	82.7	32.0	22.3	16.8	7.9	4.3	3.7	736.5
2000	104.9	91.7	83.4	32.8	35.4	34.8	37.7	177.1	87.2	33.8	23.5	17.7	8.4	4.5	3.9	776.8
2001	105.7	92.4	84.0	33.1	35.7	35.0	37.9	178.3	87.8	34.0	23.7	17.8	8.4	4.5	3.9	782.2
2002	109.5	95.8	87.0	34.3	37.0	36.3	39.3	184.8	91.1	35.3	24.5	18.5	8.7	4.7	4.0	810.8
2003	112.5	98.4	89.4	35.2	38.0	37.3	40.4	189.8	93.5	36.2	25.2	19.0	9.0	4.8	4.1	832.8
2004	107.1	93.6	85.1	33.5	36.1	35.5	38.4	180.7	89.0	34.5	24.0	18.1	8.5	4.6	3.9	792.6
2005	109.0	95.3	86.6	34.1	36.8	36.1	39.1	183.8	90.6	35.1	24.4	18.4	8.7	4.7	4.0	806.5
2006	99.2	86.7	78.8	31.0	33.5	32.9	35.6	167.3	82.5	31.9	22.2	16.7	7.9	4.3	3.7	734.2
2007	96.9	84.7	77.0	30.3	32.7	32.1	34.8	163.5	80.6	31.2	21.7	16.4	7.7	4.2	3.6	717.4
2008	100.2	87.6	79.6	31.4	33.8	33.2	36.0	169.1	83.3	32.3	22.4	16.9	8.0	4.3	3.7	742.0
2009	95.8	83.7	76.1	30.0	32.3	31.7	34.4	161.6	79.6	30.9	21.4	16.2	7.6	4.1	3.5	709.0
2010	100.5	87.9	79.9	31.5	33.9	33.3	36.1	169.6	83.6	32.4	22.5	17.0	8.0	4.3	3.7	744.1
2011	101.2	88.5	80.4	31.7	34.1	33.5	36.3	170.7	84.1	32.6	22.7	17.1	8.1	4.3	3.7	748.9
2012	108.7	95.0	86.4	34.0	36.7	36.0	39.0	183.4	90.4	35.0	24.3	18.3	8.7	4.7	4.0	804.5
2013	117.5	102.7	93.3	36.7	39.6	38.9	42.2	198.2	97.6	37.8	26.3	19.8	9.4	5.0	4.3	869.4
2014	128.9	112.7	102.4	40.3	43.5	42.7	46.3	217.5	107.2	41.5	28.9	21.8	10.3	5.5	4.7	954.3
2015	135.8	118.8	107.9	42.5	45.8	45.0	48.8	229.2	112.9	43.8	30.4	22.9	10.8	5.8	5.0	1,005.4
2016	137.9	120.6	109.6	43.2	46.5	45.7	49.5	232.7	114.7	44.4	30.9	23.3	11.0	5.9	5.1	1,021.1
2017	129.8	113.5	103.2	40.6	43.8	43.0	46.6	219.1	107.9	41.8	29.1	21.9	10.4	5.6	4.8	961.1

Emission factor:

Emission factors for this category were calculated as described in the IPCC GPG - Tier 2 approach. Equation 10.21 from IPCC 2006 (Chapter 10, p. 10.31) was used to estimate CH_4 Emission Factor for enteric fermentation from cattle:

$$EF = \left[\frac{GE \times \left(\frac{Y_m}{100} \right) \times 365}{55.65} \right]$$

Where:

EF emission factor, kg CH4/head/year

GE gross energy intake, MJ/head/day

Y_m methane conversion factor, % of gross energy in feed converted to methane. Default value for Eastern Europe Y_m =0.065 is used (IPCC 2006, Chapter 10, p.10.72, table 10A.1).

The factor 55.65 (MJ/kg CH4) is the energy content of methane.

Equation 10.16 from IPCC 2006 (Chapter 10, p.10.21) is used for calculating GE.

$$GE = \frac{\left(\frac{NE_m + NE_a + NE_1 + NE_{work} + NE_p}{REM}\right) + \left(\frac{NE_g}{REG}\right)}{\frac{DE\%}{100}}$$

where:

GE gross energy, MJ/day

NE_m Net energy for maintenance (MJ/day). $NE_m = Cf_i \times (weight)^{0.75}$. Cf_i=0.322 for non- lactating cattle and Cf_i =0.386 for lactating cattle (IPCC 2006, Chapter 10, p.10.16, table 10.4).

NE_a Net energy for animal activity (MJ/day). $NE_a = C_a \times NE_m$. C_a coefficient corresponds to animal feeding conditions. In Georgia cattle usually grazes on pastures and hilly areas, hence much energy is wasted in feeding.
According to IPCC 2006 (Chapter 10,p.10.17, Table 10.5)) in these conditions C_a=0.36.

NE_l Net energy for lactation (MJ/day). NE_l=daily milk amount× (1.47+0.40×fattiness) IPCC 2006 (Chapter 10, p.10.18, equation 10.8). Daily milk means daily milk yield. Fattiness is fat content of milk (%)

NE_{work} Net energy for work, MJ/day. $NE_w = 0.10 \times NE_m \times$ hours of work per day (IPCC 2006, Chapter 10, p.10.11, equation 10.11). It was assumed that bulls work for 1 hour per day.

NE_p Net energy required for pregnancy (MJ/day). $NE_p = C_{pregnancy} \times NE_m$ (IPCC 2006, Chapter 10, p.10.20, Equation 10.13), $C_{pregnancy}$ is pregnancy coefficient. For cattle $C_{pregnancy}$ =0.1 (IPCC 2006, Chapter 10, p.10.20, table 10.7).

REM Ratio of net energy available in a diet for maintenance to digestible energy consumed

$$REM = \left[1.123 - (4.092 \times 10^{-3} \times DE\%) + [1.126 \times 10^{-5} \times (DE\%)^2] - \left(\frac{25.4}{DE\%}\right)\right]$$

(IPCC 2006, Chapter 10, p.10.20, Equation 10.14)

DE% digestible energy expressed as a percentage of gross energy. Based on estimates for the former USSR, default value DE =60% (IPCC 2006, Chapter 10, p.10.72, table 10A.1) is used.

NE_g net energy needed for growth, MJ/day.

$$NE_g = 22.02 \times \left(\frac{BW}{C \times MW}\right)^{0.75} \times WG^{1.097}$$

(IPCC 2006, Chapter 10, p.10.17, equation 10.6)

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

WG The average daily weight gain of the animals in the population, kg day-1

REG Ratio of net energy available for growth in a diet to digestible energy consumed. (IPCC 2006, Chapter 10, p.10.21, Eq. 10.15)

$$REG = \left[1.164 - (5.160 \times 10^{-3} \times DE\%) + \left[1.308 \times 10^{-5} \times (DE\%)^2 - \left(\frac{37.4}{DE\%}\right)\right]\right]$$

Actvity data:
Necessary data for calculations are given in Table 4-58 - Table 4-60.

Table 4-58 Females live-weight standards

Breed	live weight by moths, kg														
	Newborn	6	7	8	9	10	12	15	18	24	30	36	48	60	72
Georgian Mountain	13	55	60	70	80	85	100	115	130	135	157	169	180	200	210
Red Mingrelian	15	75	85	95	105	115	130	160	190	200	217	234	250	280	300
Early maturing	32	152	168	187	203	220	250	297	345	397	420	443	487	520	520

Table 4-59 Males live-weight standards

Breed	live weight by moths, kg														
	Newborn	6	7	8	9	10	12	15	18	24	30	36	48	60	72
Georgian Mountain	13	60	65	75	85	95	110	140	160	190	220	255	290	320	320
Red Mingrelian	15	80	90	100	110	125	160	200	210	310	350	390	460	480	480
Early maturing	32	170	195	225	240	263	310	385	458	543	613	693	773	820	820

Table 4-60 Average milk production and average fat content for cows

Breed	Fat, %	Milk production, kg							
		Averaged in herd		1st lactation		2nd lactation		3rd and more lactation	
		Per year	Per day	Per year	Per day	Per year	Per day	Per year	Per day
Georgian Mountain	4.3	1,358	3.7	1,228	3.4	1,302	3.6	1,376	3.8
Red Mingrelian	4.3	1,460	4.0	1,047	2.9	1,269	3.5	1,491	4.1
Early maturing	3.7	2,610	7.1	2,349	6.4	2,597	7.1	2,845	7.8

Emission factors:
The calculated emission factors for cattle are given in *Table 4-61*.

Table 4-61 Estimated methane emission factors

Cattle category	Age, year	Emission factor, $kgCH_4$/head	
		Georgian mountain	Red Mingrelian
Calf – females	0-1	13	16
Heifer	1-2	29	40
Heifer	2-3	34	43
Heifer	3-4	34	44
Cow	4-5	37	49
Lactating cow	4-5	52	61
Cow	5-6	38	50
Lactating cow	5-6	53	66
Cow	>6	37	49
Lactating cow	>6	53	65
Calf – males	0-1	13	17
Bullock	1-2	36	53
Bullock	2-3	45	63
Bullock	3-4	49	71
Bull (castrate)	4-5	56	76
Bull (castrate)	5-6	55	75
Bull (castrate)	>6	55	65

Cattle category	Age, year	Emission factor, $kgCH_4$/head
		Early maturing
Calf – females	0-1	28
Heifer	1-2	70
Heifer	2-3	70
Cow	3-4	74
Lactating cow	3-4	90
Cow	4-5	77
Lactating cow	4-5	94
Cow	>5	74
Lactating cow	>5	94
Calf – males	0-1	30
Bullock	1-2	85
Bullock	2-3	101
Bull (castrate)	3-4	112
Bull (castrate)	4-5	114
Bull (castrate)	>5	111

Emissions:

The estimated emissions from cattle are given in *Table 4-62 - Table 4-64.*

Table 4-62 Estimated methane emissions for Georgian Mountain cattle in 1990-2017 years

	Emissions, Gg CH_4																	
Cattle category	**Calf – females**	**Heifer**	**Heifer**	**Heifer**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Calf – males**	**Bullock**	**Bullock**	**Bullock**	**Bull (castrate)**	**Bull (castrate)**	**Bull (castrate)**	**Total**
Age, year	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**4-5**	**5-6**	**5-6**	**>6**	**>6**	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**>6**	
1990	0.46	0.80	0.84	0.82	0.38	0.58	0.37	0.56	3.08	2.18	0.14	0.35	0.35	0.31	0.15	0.12	0.07	**11.60**
1991	0.43	0.74	0.77	0.76	0.36	0.54	0.34	0.52	2.85	2.01	0.13	0.32	0.32	0.29	0.14	0.11	0.07	**10.70**
1992	0.35	0.61	0.64	0.62	0.29	0.44	0.28	0.43	2.34	1.66	0.11	0.26	0.26	0.24	0.11	0.09	0.06	**8.80**
1993	0.32	0.56	0.59	0.57	0.27	0.41	0.26	0.39	2.17	1.53	0.10	0.24	0.24	0.22	0.10	0.08	0.05	**8.10**
1994	0.33	0.57	0.59	0.58	0.27	0.42	0.26	0.40	2.19	1.55	0.10	0.25	0.25	0.22	0.11	0.08	0.05	**8.20**
1995	0.34	0.58	0.61	0.60	0.28	0.43	0.27	0.41	2.25	1.59	0.10	0.25	0.25	0.23	0.11	0.08	0.05	**8.40**
1996	0.35	0.60	0.63	0.61	0.29	0.44	0.28	0.42	2.31	1.63	0.11	0.26	0.26	0.24	0.11	0.09	0.05	**8.70**
1997	0.35	0.61	0.64	0.62	0.29	0.44	0.28	0.43	2.34	1.65	0.11	0.26	0.26	0.24	0.11	0.09	0.06	**8.80**
1998	0.36	0.62	0.65	0.63	0.30	0.45	0.29	0.43	2.38	1.68	0.11	0.27	0.27	0.24	0.11	0.09	0.06	**8.90**
1999	0.38	0.66	0.69	0.67	0.31	0.48	0.30	0.46	2.53	1.78	0.12	0.28	0.29	0.26	0.12	0.10	0.06	**9.50**
2000	0.40	0.68	0.71	0.70	0.33	0.50	0.32	0.48	2.63	1.86	0.12	0.30	0.30	0.27	0.13	0.10	0.06	**9.90**
2001	0.39	0.68	0.71	0.70	0.33	0.50	0.32	0.48	2.62	1.85	0.12	0.30	0.30	0.27	0.13	0.10	0.06	**9.80**
2002	0.40	0.70	0.73	0.71	0.33	0.51	0.32	0.49	2.68	1.89	0.12	0.30	0.30	0.27	0.13	0.10	0.06	**10.10**
2003	0.41	0.71	0.74	0.72	0.34	0.52	0.33	0.50	2.72	1.92	0.13	0.31	0.31	0.28	0.13	0.10	0.06	**10.20**
2004	0.38	0.66	0.69	0.68	0.32	0.49	0.31	0.47	2.56	1.81	0.12	0.29	0.29	0.26	0.12	0.10	0.06	**9.60**
2005	0.39	0.67	0.70	0.68	0.32	0.49	0.31	0.47	2.57	1.82	0.12	0.29	0.29	0.26	0.12	0.10	0.06	**9.70**
2006	0.35	0.60	0.63	0.61	0.29	0.44	0.28	0.42	2.32	1.63	0.11	0.26	0.26	0.24	0.11	0.09	0.05	**8.70**
2007	0.34	0.58	0.61	0.59	0.28	0.42	0.27	0.41	2.24	1.58	0.10	0.25	0.25	0.23	0.11	0.08	0.05	**8.40**
2008	0.34	0.59	0.62	0.61	0.28	0.43	0.28	0.42	2.28	1.61	0.11	0.26	0.26	0.23	0.11	0.09	0.05	**8.60**
2009	0.32	0.56	0.58	0.57	0.27	0.41	0.26	0.39	2.16	1.52	0.10	0.24	0.24	0.22	0.10	0.08	0.05	**8.10**
2010	0.34	0.58	0.61	0.59	0.28	0.42	0.27	0.41	2.23	1.58	0.10	0.25	0.25	0.23	0.11	0.08	0.05	**8.40**
2011	0.32	0.55	0.58	0.57	0.27	0.41	0.26	0.39	2.14	1.51	0.10	0.24	0.24	0.22	0.10	0.08	0.05	**8.00**
2012	0.33	0.57	0.59	0.58	0.27	0.41	0.26	0.40	2.18	1.54	0.10	0.25	0.25	0.22	0.10	0.08	0.05	**8.20**
2013	0.34	0.58	0.61	0.59	0.28	0.42	0.27	0.41	2.24	1.58	0.10	0.25	0.25	0.23	0.11	0.08	0.05	**8.40**
2014	0.35	0.60	0.63	0.62	0.29	0.44	0.28	0.42	2.33	1.65	0.11	0.26	0.26	0.24	0.11	0.09	0.06	**8.80**
2015	0.35	0.60	0.63	0.62	0.29	0.44	0.28	0.42	2.33	1.64	0.11	0.26	0.26	0.24	0.11	0.09	0.05	**8.70**
2016	0.35	0.61	0.64	0.63	0.29	0.45	0.29	0.43	2.37	1.67	0.11	0.27	0.27	0.24	0.11	0.09	0.06	**8.90**
2017	0.33	0.58	0.60	0.59	0.28	0.42	0.27	0.41	2.23	1.57	0.10	0.25	0.25	0.23	0.11	0.08	0.05	**8.40**

Table 4-63 Estimated methane emissions for Red Mingrelian cattle in 1990-2017 years

	Emissions, Gg CH_4																	
Cattle category	**Calf – females**	**Heifer**	**Heifer**	**Heifer**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Calf – males**	**Bullock**	**Bullock**	**Bullock**	**Bull (castrate)**	**Bull (castrate)**	**Bull (castrate)**	**Total**
Age, year	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**4-5**	**5-6**	**5-6**	**>6**	**>6**	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**>6**	
1990	0.38	0.74	0.71	0.71	0.34	0.46	0.33	0.47	2.74	1.79	0.13	0.34	0.33	0.31	0.14	0.11	0.06	**10.10**
1991	0.35	0.68	0.66	0.66	0.32	0.42	0.30	0.43	2.53	1.65	0.12	0.32	0.30	0.28	0.12	0.10	0.05	**9.30**
1992	0.29	0.56	0.54	0.54	0.26	0.35	0.25	0.35	2.07	1.35	0.09	0.26	0.25	0.23	0.10	0.08	0.04	**7.60**
1993	0.27	0.51	0.49	0.49	0.24	0.32	0.23	0.33	1.91	1.25	0.09	0.24	0.23	0.21	0.09	0.07	0.04	**7.00**
1994	0.27	0.52	0.50	0.50	0.24	0.32	0.23	0.33	1.92	1.26	0.09	0.24	0.23	0.21	0.09	0.07	0.04	**7.10**
1995	0.27	0.53	0.51	0.51	0.24	0.33	0.24	0.34	1.96	1.28	0.09	0.25	0.23	0.22	0.10	0.08	0.04	**7.20**
1996	0.28	0.54	0.52	0.52	0.25	0.34	0.24	0.34	2.01	1.31	0.09	0.25	0.24	0.22	0.10	0.08	0.04	**7.40**
1997	0.28	0.55	0.53	0.53	0.25	0.34	0.24	0.35	2.03	1.32	0.09	0.25	0.24	0.23	0.10	0.08	0.04	**7.50**

	Emissions, Gg CH_4																	
Cattle category	**Calf – females**	**Heifer**	**Heifer**	**Heifer**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Calf – males**	**Bullock**	**Bullock**	**Bullock**	**Bull (castrate)**	**Bull (castrate)**	**Bull (castrate)**	**Total**
Age, year	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**4-5**	**5-6**	**5-6**	**>6**	**>6**	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**>6**	
1998	0.29	0.55	0.53	0.53	0.26	0.34	0.25	0.35	2.05	1.34	0.09	0.26	0.24	0.23	0.10	0.08	0.04	**7.50**
1999	0.30	0.59	0.56	0.56	0.27	0.36	0.26	0.37	2.17	1.42	0.10	0.27	0.26	0.24	0.11	0.08	0.05	**8.00**
2000	0.31	0.61	0.58	0.58	0.28	0.38	0.27	0.38	2.25	1.47	0.10	0.28	0.27	0.25	0.11	0.09	0.05	**8.30**
2001	0.31	0.60	0.58	0.58	0.28	0.37	0.27	0.38	2.23	1.46	0.10	0.28	0.27	0.25	0.11	0.09	0.05	**8.20**
2002	0.32	0.61	0.59	0.59	0.28	0.38	0.27	0.39	2.27	1.48	0.10	0.28	0.27	0.25	0.11	0.09	0.05	**8.40**
2003	0.32	0.62	0.59	0.60	0.29	0.39	0.27	0.39	2.29	1.50	0.10	0.29	0.27	0.26	0.11	0.09	0.05	**8.40**
2004	0.30	0.58	0.56	0.56	0.27	0.36	0.26	0.37	2.15	1.40	0.10	0.27	0.26	0.24	0.11	0.08	0.05	**7.90**
2005	0.30	0.58	0.56	0.56	0.27	0.36	0.26	0.37	2.15	1.40	0.10	0.27	0.26	0.24	0.11	0.08	0.05	**7.90**
2006	0.27	0.52	0.50	0.50	0.24	0.32	0.23	0.33	1.92	1.26	0.09	0.24	0.23	0.21	0.09	0.07	0.04	**7.10**
2007	0.26	0.50	0.48	0.48	0.23	0.31	0.22	0.32	1.85	1.21	0.08	0.23	0.22	0.21	0.09	0.07	0.04	**6.80**
2008	0.26	0.51	0.49	0.49	0.23	0.32	0.22	0.32	1.88	1.23	0.09	0.24	0.22	0.21	0.09	0.07	0.04	**6.90**
2009	0.25	0.48	0.46	0.46	0.22	0.30	0.21	0.30	1.76	1.15	0.08	0.22	0.21	0.20	0.09	0.07	0.04	**6.50**
2010	0.25	0.49	0.47	0.47	0.23	0.30	0.22	0.31	1.82	1.19	0.08	0.23	0.22	0.20	0.09	0.07	0.04	**6.70**
2011	0.23	0.45	0.43	0.43	0.21	0.28	0.20	0.29	1.68	1.10	0.08	0.21	0.20	0.19	0.08	0.07	0.04	**6.20**
2012	0.23	0.44	0.43	0.43	0.20	0.28	0.20	0.28	1.64	1.07	0.08	0.21	0.20	0.18	0.08	0.06	0.03	**6.00**
2013	0.23	0.44	0.42	0.42	0.20	0.27	0.19	0.28	1.61	1.06	0.07	0.20	0.19	0.18	0.08	0.06	0.03	**5.90**
2014	0.22	0.43	0.41	0.42	0.20	0.27	0.19	0.27	1.60	1.05	0.07	0.20	0.19	0.18	0.08	0.06	0.03	**5.90**
2015	0.21	0.41	0.39	0.39	0.19	0.25	0.18	0.26	1.51	0.99	0.07	0.19	0.18	0.17	0.07	0.06	0.03	**5.60**
2016	0.21	0.42	0.40	0.40	0.19	0.26	0.18	0.26	1.54	1.00	0.07	0.19	0.18	0.17	0.08	0.06	0.03	**5.70**
2017	0.20	0.39	0.37	0.38	0.18	0.24	0.17	0.25	1.45	0.95	0.07	0.18	0.17	0.16	0.07	0.06	0.03	**5.30**

Table 4-64 Estimated methane emissions for early maturing cattle in 1990-2017 years

	Emissions, Gg CH_4															
Cattle category	**Calf – females**	**Heifer**	**Heifer**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Calf – males**	**Bullock**	**Bullock**	**Bull (castrate)**	**Bull (castrate)**	**Bull (castrate)**	**Total**
Age, year	**0-1**	**1-2**	**2-3**	**3-4**	**3-4**	**4-5**	**4-5**	**>5**	**>5**	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**>5**	
1990	3.05	6.67	6.06	2.52	3.31	2.78	3.68	13.60	8.52	1.05	2.07	1.86	0.97	0.53	0.45	**56.70**
1991	2.86	6.24	5.67	2.36	3.10	2.60	3.44	12.74	7.97	0.99	1.94	1.74	0.91	0.50	0.42	**53.10**
1992	2.38	5.20	4.72	1.97	2.58	2.17	2.86	10.60	6.63	0.82	1.62	1.45	0.76	0.42	0.35	**44.20**
1993	2.22	4.86	4.41	1.84	2.41	2.02	2.68	9.91	6.20	0.77	1.51	1.35	0.71	0.39	0.32	**41.30**
1994	2.28	4.98	4.52	1.88	2.47	2.07	2.74	10.15	6.35	0.79	1.55	1.39	0.73	0.40	0.33	**42.30**
1995	2.36	5.16	4.69	1.95	2.56	2.15	2.85	10.53	6.59	0.82	1.61	1.44	0.75	0.41	0.34	**43.90**
1996	2.46	5.38	4.89	2.03	2.67	2.24	2.96	10.97	6.86	0.85	1.67	1.50	0.78	0.43	0.36	**45.70**
1997	2.52	5.51	5.00	2.08	2.73	2.30	3.04	11.24	7.03	0.87	1.71	1.53	0.80	0.44	0.37	**46.80**
1998	2.59	5.67	5.15	2.14	2.81	2.36	3.12	11.56	7.24	0.89	1.76	1.58	0.83	0.45	0.38	**48.20**
1999	2.79	6.09	5.53	2.30	3.02	2.54	3.36	12.42	7.78	0.96	1.89	1.70	0.89	0.49	0.41	**51.80**
2000	2.94	6.42	5.84	2.43	3.19	2.68	3.54	13.10	8.20	1.01	2.00	1.79	0.94	0.51	0.43	**54.60**
2001	2.96	6.47	5.88	2.45	3.21	2.70	3.56	13.19	8.26	1.02	2.01	1.80	0.94	0.52	0.43	**55.00**
2002	3.07	6.70	6.09	2.54	3.33	2.79	3.70	13.68	8.56	1.06	2.08	1.87	0.98	0.54	0.45	**57.00**
2003	3.15	6.89	6.26	2.61	3.42	2.87	3.80	14.05	8.79	1.09	2.14	1.92	1.01	0.55	0.46	**58.50**
2004	3.00	6.55	5.96	2.48	3.25	2.73	3.61	13.37	8.37	1.03	2.04	1.82	0.96	0.52	0.44	**55.70**
2005	3.05	6.67	6.06	2.52	3.31	2.78	3.68	13.60	8.51	1.05	2.07	1.86	0.97	0.53	0.45	**56.70**
2006	2.78	6.07	5.52	2.30	3.01	2.53	3.35	12.38	7.75	0.96	1.89	1.69	0.89	0.49	0.41	**51.60**
2007	2.71	5.93	5.39	2.24	2.94	2.47	3.27	12.10	7.57	0.94	1.84	1.65	0.87	0.47	0.40	**50.40**

	Emissions, Gg CH_4															
Cattle category	**Calf – females**	**Heifer**	**Heifer**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Cow**	**Lactating cow**	**Calf – males**	**Bullock**	**Bullock**	**Bull (castrate)**	**Bull (castrate)**	**Bull (castrate)**	**Total**
Age, year	**0-1**	**1-2**	**2-3**	**3-4**	**3-4**	**4-5**	**4-5**	**>5**	**>5**	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**>5**	
2008	2.81	6.13	5.58	2.32	3.04	2.56	3.38	12.52	7.83	0.97	1.91	1.71	0.90	0.49	0.41	**52.10**
2009	2.68	5.86	5.33	2.22	2.91	2.44	3.23	11.96	7.48	0.93	1.82	1.63	0.86	0.47	0.39	**49.80**
2010	2.81	6.15	5.59	2.33	3.05	2.56	3.39	12.55	7.86	0.97	1.91	1.71	0.90	0.49	0.41	**52.30**
2011	2.83	6.19	5.63	2.34	3.07	2.58	3.41	12.63	7.91	0.98	1.93	1.72	0.90	0.50	0.41	**52.60**
2012	3.04	6.65	6.04	2.52	3.30	2.77	3.67	13.57	8.49	1.05	2.07	1.85	0.97	0.53	0.44	**56.50**
2013	3.29	7.19	6.53	2.72	3.57	3.00	3.96	14.66	9.18	1.13	2.24	2.00	1.05	0.58	0.48	**61.10**
2014	3.61	7.89	7.17	2.99	3.92	3.29	4.35	16.10	10.07	1.25	2.45	2.20	1.15	0.63	0.53	**67.10**
2015	3.80	8.31	7.55	3.15	4.13	3.47	4.58	16.96	10.61	1.31	2.59	2.31	1.21	0.67	0.56	**70.70**
2016	3.86	8.44	7.67	3.19	4.19	3.52	4.65	17.22	10.78	1.33	2.63	2.35	1.23	0.68	0.56	**71.80**
2017	3.64	7.95	7.22	3.01	3.94	3.31	4.38	16.21	10.15	1.25	2.47	2.21	1.16	0.64	0.53	**67.50**

Methane emissions from enteric fermentation in cattle estimated on the basis of tier 2 approach are presented in summary *Table 4-65*.

Table 4-65 Methane emissions in Gg from enteric fermentation in cattle

Year	**Methane emissions**				
	Early maturing	**Georgian Mountain**	**Red Mingrelian**	**Total, Gg CH_4**	**Total, Gg CO_2eq**
1990	56.68	11.56	10.08	**78.32**	**1,645**
1991	53.07	10.70	9.30	**73.07**	**1,534**
1992	44.16	8.80	7.61	**60.57**	**1,272**
1993	41.27	8.12	7.00	**56.40**	**1,184**
1994	42.30	8.23	7.07	**57.59**	**1,209**
1995	43.88	8.44	7.21	**59.53**	**1,250**
1996	45.69	8.68	7.39	**61.76**	**1,297**
1997	46.81	8.79	7.45	**63.04**	**1,324**
1998	48.16	8.93	7.54	**64.63**	**1,357**
1999	51.75	9.48	7.97	**69.21**	**1,453**
2000	54.58	9.88	8.27	**72.74**	**1,528**
2001	54.96	9.83	8.19	**72.99**	**1,533**
2002	56.97	10.07	8.35	**75.39**	**1,583**
2003	58.52	10.22	8.43	**77.18**	**1,621**
2004	55.70	9.61	7.89	**73.20**	**1,537**
2005	56.68	9.66	7.90	**74.23**	**1,559**
2006	51.59	8.69	7.06	**67.35**	**1,414**
2007	50.41	8.39	6.78	**65.58**	**1,377**
2008	52.14	8.57	6.90	**67.61**	**1,420**
2009	49.82	8.09	6.47	**64.38**	**1,352**
2010	52.29	8.38	6.68	**67.35**	**1,414**
2011	52.63	8.02	6.16	**66.81**	**1,403**
2012	56.54	8.19	6.04	**70.77**	**1,486**
2013	61.09	8.40	5.94	**75.43**	**1,584**
2014	67.06	8.75	5.89	**81.70**	**1,716**
2015	70.65	8.74	5.56	**84.96**	**1,784**
2016	71.75	8.88	5.65	**86.28**	**1,812**
2017	67.53	8.36	5.32	**81.21**	**1,705**

4.11.2. Buffalo, Sheep, Goats, Horses, Asses & Swine (3.A.2, 3.A.3, 3.A.4, 3.A.5.1, 3.A.5.2, 3.A.6)

Methodology:

The IPCC 2006 methodology is used for estimating methane emissions from enteric fermentation for Buffalo, Sheep, Goats, Horses, Asses and Swine,. The amount of methane emitted by a population of animals is calculated by multiplying the emission rate per animal by the number of animals.

$$EN_i = EF_i \times Pop_i$$

Where:

EM_i	emissions from animal type i
i	index refers to animal type
EF_i	methane emission factor for animal type i
Pop_i	quantity of animal type i

Activity data:

Numbers of animals in 1990-2017 years are given in *Table 4-66*.

Table 4-66 The number of animals (thousand heads)

Year	Buffalos 3.A.2	Sheep 3.A.3	Goats 3.A.4	Horses 3.A.5.1	Asses 3.A.5.2	Swine 3.A.6	Poultry
1990	37	1,550	68	20	NE	880	21,760
1991	33	1,411	59	18	NE	733	20,167
1992	30	1,146	45	17	NE	476	11,210
1993	24	920	38	20	NE	365	11,857
1994	22	754	39	21	NE	367	12,290
1995	22	674	51	24	NE	353	13,847
1996	22	600	52	26	NE	333	14,645
1997	23	525	59	28	9	330	15,542
1998	23	522	65	30	11	366	8,240
1999	23	553	80	34	12	411	8,473
2000	24	547	81	35	NE	443	7,826
2001	24	568	92	39	11	445	8,495
2002	24	611	88	43	NE	446	8,899
2003	24	629	93	43	NE	474	9,201
2004	24	689	116	44	13	484	9,836
2005	22	720	96	43	13	455	7,482
2006	22	697	92	26	8	344	5,401
2007	19	711	86	23	9	110	6,150
2008	18	690	79	28	8	86	6,682
2009	18	602	72	29	7	135	6,675
2010	17	597	57	31	11	110	6,522
2011	17	577	54	29	8	105	6,360
2012	17	688	54	31	6	204	6,159
2013	18	796	61	31	8	191	6,761
2014	12	866	54	28	7	170	6,658
2015	15	842	50	34	4	162	8,309
2016	17	876	61	23	4	136	8,238
2017	15	856	51	22	3	151	8,386

Emission factors:

Emission factors are taken according to default values for developing countries with temperate climate [IPCC 2006, Chapter 10, p. 10.28, table 10.10].

Emissions:

CH_4 emissions from enteric fermentation for Buffalos, Sheep, Goats, Horses, Asses and Swine, are presented in *Table 4-67*.

Table 4-67 Methane emissions (in Gg) from enteric fermentation in Buffalos, Sheep, Goats, Horses, Asses and Swine

Year	Buffalos 3.A.2	Sheep 3.A.3	Goats 3.A.4	Horses 3.A.5.1	Asses 3.A.5.2	Swine 3.A.6	Total	Total Gg-CO2eq
1990	2.02	7.75	0.34	0.35	NE	0.88	11.35	238
1991	1.81	7.06	0.29	0.33	NE	0.73	10.22	215
1992	1.65	5.73	0.23	0.30	NE	0.48	8.39	176
1993	1.35	4.60	0.19	0.35	NE	0.37	6.85	144
1994	1.22	3.77	0.20	0.39	NE	0.37	5.94	125
1995	1.22	3.37	0.25	0.43	NE	0.35	5.63	118
1996	1.23	3.00	0.26	0.47	NE	0.33	5.30	111
1997	1.25	2.62	0.30	0.50	0.09	0.33	5.09	107
1998	1.25	2.61	0.33	0.55	0.11	0.37	5.20	109
1999	1.25	2.77	0.40	0.61	0.12	0.41	5.56	117
2000	1.31	2.73	0.40	0.63	NE	0.44	5.52	116
2001	1.34	2.84	0.46	0.69	0.11	0.45	5.89	124
2002	1.32	3.06	0.44	0.77	NE	0.45	6.03	127
2003	1.33	3.14	0.47	0.78	NE	0.47	6.19	130
2004	1.32	3.45	0.58	0.80	0.13	0.48	6.76	142
2005	1.23	3.60	0.48	0.77	0.13	0.46	6.66	140
2006	1.21	3.48	0.46	0.47	0.08	0.34	6.05	127
2007	1.07	3.56	0.43	0.41	0.09	0.11	5.66	119
2008	1.01	3.45	0.40	0.50	0.08	0.09	5.53	116
2009	0.98	3.01	0.36	0.52	0.07	0.14	5.07	107
2010	0.93	2.98	0.29	0.55	0.11	0.11	4.97	104
2011	0.93	2.88	0.27	0.53	0.08	0.11	4.80	101
2012	0.94	3.44	0.27	0.55	0.06	0.20	5.47	115
2013	1.00	3.98	0.30	0.55	0.08	0.19	6.11	128
2014	0.65	4.33	0.27	0.51	0.07	0.17	6.00	126
2015	0.85	4.21	0.25	0.61	0.04	0.16	6.12	129
2016	0.92	4.38	0.30	0.41	0.04	0.14	6.19	130
2017	0.80	4.28	0.26	0.40	0.03	0.15	5.91	124

4.12. Manure Management (3.B.)

During handling or storage of livestock manure, both CH_4 and N_2O are emitted. The magnitude of the emissions depends upon the quantity of manure handled, the manure properties, and the type of manure management system. Typically, poorly aerated manure management systems generate large quantities of CH_4 but smaller amounts of N_2O, while well-aerated systems generate little CH_4 but larger volume of N_2O.

4.12.1. Methane Emissions from Manure Management (3.B.1)

Shortly after manure is excreted, it begins to decompose. If little oxygen is present, the decomposition will be mainly anaerobic and thus produces CH_4. The quantity of CH_4 produced depends on the type of waste management system, the degree of aeration, and the quantity of manure.

Methane emissions from cattle manure management are estimated using the IPCC Tier 2 approach.

$$EF_{(T)} = \left(VS_{(T)} \times 365\right) \times \left[B_{o(T)} \times 0.67kg/m^3 \times \sum_{S,k} \frac{MCF_{S,k}}{100} \times MS_{(T,S,k)}\right]$$

Where:

$EF_{(T)}$	annual CH_4 emission factor for livestock category T, kgCH4/animal/year
$VS_{(T)}$	daily volatile solid excreted for livestock category T, kg dry matter/animal/day
365	basis for calculating annual VS production, days yr-1

$Bo_{(T)}$ maximum methane producing capacity for manure produced by livestock category *T*, m3 CH_4 kg-1 of VS excreted

0.67 conversion factor of m^3 CH_4 to kilograms CH_4

MCF(S,k) methane conversion factors for each manure management system *S* by climate region *k*, %

MS(T,S,k) fraction of livestock category *T*'s manure handled using manure management system *S* in climate region *k*, dimensionless

For other types of animals the IPCC Tier 1 approach was used. This approach relies on default emission factors.

Activity Data:
The animal population data are the same as those used for the Enteric Fermentation emission estimates (*Table 4-54*and *Table 4-66*).

Emission factors:
Due to absence of country specific data on VS and Bo, default values from the 2006 IPCC (Reference Manual, chapter 10, tables 10A4, 10A5) have been used. Emission factors for buffalo and swine were taken according to default values for Asia region [IPCC 2006, Chapter 10, p. 10.38-10.39, table 10.14]. For other types of animals (goats, horses, asses and poultry) emission factors are taken according to default values for developing countries with temperature from 15°C to 25°C (temperate climate) [IPCC 2006, Chapter 10, p. 10.40, table 10.15].

Emissions:
Calculated methane emissions from manure management are presented in *Table 4-68*.

Table 4-68 Methane emissions (in Gg) from manure management

Year	Cattle 3.B.1.1	Buffalos 3.B.1.2	Sheep 3.B.1.3	Goats 3.B.1.4	Horses 3.B.1.5.a	Asses 3.B.1.5.b	Swine 3.B.1.6	Poultry 3.B.1.7	Total	Total Gg CO_2eq
1990	1.50	0.07	0.23	0.01	0.03	NE	3.52	0.44	5.80	122
1991	1.40	0.07	0.21	0.01	0.03	NE	2.93	0.40	5.05	106
1992	1.16	0.06	0.17	0.01	0.03	NE	1.90	0.22	3.55	75
1993	1.07	0.05	0.14	0.01	0.03	NE	1.46	0.24	3.00	63
1994	1.09	0.04	0.11	0.01	0.04	NE	1.47	0.25	3.01	63
1995	1.13	0.04	0.10	0.01	0.04	NE	1.41	0.28	3.01	63
1996	1.17	0.04	0.09	0.01	0.04	NE	1.33	0.29	2.98	63
1997	1.19	0.05	0.08	0.01	0.05	0.01	1.32	0.31	3.01	63
1998	1.22	0.05	0.08	0.01	0.05	0.01	1.46	0.16	3.04	64
1999	1.31	0.05	0.08	0.01	0.06	0.01	1.64	0.17	3.33	70
2000	1.37	0.05	0.08	0.01	0.06	NE	1.77	0.16	3.50	74
2001	1.37	0.05	0.09	0.02	0.06	0.01	1.78	0.17	3.55	74
2002	1.42	0.05	0.09	0.02	0.07	NE	1.78	0.18	3.60	76
2003	1.45	0.05	0.09	0.02	0.07	NE	1.90	0.18	3.76	79
2004	1.37	0.05	0.10	0.02	0.07	0.01	1.94	0.20	3.76	79
2005	1.39	0.04	0.11	0.02	0.07	0.01	1.82	0.15	3.61	76
2006	1.26	0.04	0.10	0.02	0.04	0.01	1.37	0.11	2.95	62
2007	1.22	0.04	0.11	0.01	0.04	0.01	0.44	0.12	1.99	42
2008	1.26	0.04	0.10	0.01	0.05	0.01	0.35	0.13	1.94	41
2009	1.20	0.04	0.09	0.01	0.05	0.01	0.54	0.13	2.06	43
2010	1.25	0.03	0.09	0.01	0.05	0.01	0.44	0.13	2.01	42
2011	1.23	0.03	0.09	0.01	0.05	0.01	0.42	0.13	1.96	41
2012	1.30	0.03	0.10	0.01	0.05	0.01	0.82	0.12	2.44	51
2013	1.37	0.04	0.12	0.01	0.05	0.01	0.76	0.14	2.50	52
2014	1.48	0.02	0.13	0.01	0.05	0.01	0.68	0.13	2.50	53
2015	1.53	0.03	0.13	0.01	0.06	NE	0.65	0.17	2.56	54
2016	1.55	0.03	0.13	0.01	0.04	NE	0.54	0.16	2.48	52
2017	1.46	0.03	0.13	0.01	0.04	NE	0.60	0.17	2.43	51

4.12.2. Nitrous oxide emissions from manure management (3.B.2)

4.12.2.1. Direct N_2O emissions from Manure Management

The production of N_2O during storage and treatment of animal waste occurs during nitrification and denitrification of nitrogen contained in the manure. Nitrification is the oxidation of ammonium (NH_4+) to nitrate (NO_3-), and denitrification is the reduction of (NO_3-) to N_2O or nitrogen (N_2). Generally, as the degree of aeration of the waste increases, so does the amount of N_2O produced.

The Animal Waste Management System (AWMS) is an important regulating factor in N_2O emissions. N_2O emissions from some types of AWMS (Anaerobic lagoons; Liquid systems; Solid storage and drylot; and other systems) are reported under Manure Management, while stable manure that is applied to agricultural soils (e.g., daily spread) and dung and urine deposited by grazing animals on fields (pasture range and paddock) is referred in the methodology for estimating direct emissions from agricultural soils. Manure used for fuel is considered an energy-related emission.

Methodology:
IPCC tier 1 method is used. Direct nitrous oxide emissions from manure management are estimated by 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. Emissions are then summed over all manure management systems. IPCC default N_2O emission factors, default nitrogen excretion data, and default manure management system data are used. The methodology is based on the following formulae:

$$N_2O_{D(mm)} = \left[\sum_S \left[\sum_T \left(N_{(T)} \times Nex_{(T)} \times MS_{(T,S)} \right) \right] \times EF_{3(S)} \right] \times \frac{44}{28}$$

Where:

N_T	number of head of livestock category T in the country
$Nex_{(T)}$	annual average N excretion per head of species/category T in the country, \ kgN/animal/year
$MS_{(T,S)}$	fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless
$EF_{3(S)}$	emission factor for direct N_2O emissions from manure management system S in the country, kgN_2O-N/kg N in manure management system S
S	manure management system
T	species/category of livestock
44/28	conversion of N_2O-N emissions to N_2O emissions

Activity data:
Animal population data and distribution by categories are taken from *Table 4-54* and *Table 4-66*.

Emission factors:
The average daily nitrogen excretion rates for domestic animals are taken according to default values for Asia region [IPCC 2006, Chapter 10, p.10.59, Table 10.19]. Herd average weight for cattle was estimated based on cattle distribution by age (*Table 4-55*

Table 4-57) and cattle weight by age (*Table 4-58, Table 4-59*). For other animal's default values are used (IPCC 2006, Chapter 10, p.10.59, Table 10.19). EF_3 are taken from the IPCC 2006 (Chapter 10, p.10.62, Table 10.21). During 1990-2017 Cattle Herd average weight varies within the range of 336.8-365 kg and Nex varies within 41.8-45.3 (average 43.2). Nex for other animals is presented in *Table 4-69*.

Table 4-69 Nitrogen Excretion rate (Nex) for animal types

Animal	Cattle	Sheep	Goats	Swine	Buffalo	Horses	Asses	Poultry
Weight, kg	348	28	30	28	380	238	130	0.9
Nex, kg N/head/day/1000kg	0.34	1.17	1.37	0.42	0.32	0.46	0.46	1.1
Nex, kg N/head/year	43.2	12	15	4.3	44.4	40	21.8	0.4

The fraction of nitrogen available for conversion into N_2O is estimated by applying system-specific values to the manure nitrogen handled by each management system. The IPCC default values for Asia region are used here [IPCC 2006, Chapter 10, pp. 10.78-10.81, tables 10A-5-10A-8], with adjustments based on the national agriculture expert (Head of the Zootechny department of the Agrarian University of Georgia Mr. Levan Tortladze) judgment (*Table 4-70*).

Table 4-70 Fraction of manure nitrogen in different management systems

Animal	Anaerobic Lagoons	Liquid Systems	Solid Storage	Drylot	Daily Spread	Pasture Range And Paddock	Other systems
Cattle	-	-	-	0.46	0.02	0.50	0.02
Poultry	-	-	-	-	-	0.44	0.56
Sheep	-	-	-	-	-	0.83	0.17
Swine	-	-	-	0.54	-	-	0.46
Others	-	-	-	-	-	0.95	0.05

Only insignificant portion of manure nitrogen transforms into nitrous oxide. N_2O emission factors (kg N_2O-N/kg emitted nitrogen) for various manure management systems are provided in *Table 4-71*. IPCC Default values are used [IPCC 2006, Chapter 10, p.10.62, table 10.21].

Table 4-71 N_2O emission factors from manure management systems (kg N_2O-N/kg emitted nitrogen)

AWMS	Anaerobic Lagoons	Liquid Systems	Solid Storage	Drylot	Daily Spread	Pasture Range And Paddock	Other systems
Emission factor - EF3	0	0.001	0.005	0.02	0.0	0.02	0.005

Emissions: Direct N_2O Emissions from different manure management systems are provided in *Table 4-72*.

Table 4-72 Direct N_2O emissions (in Gg) from manure management systems

Year	Drylot		Other systems									
	Cattle 3.B.2.1	Swine 3.B.2.6	Cattle 3.B.2.1	Buffalos 3.B.2.2	Sheep 3.B.2.3	Goats 3.B.2.4	Swine 3.B.2.6	Poultry 3.B.2.7	Total, Gg N_N2O	Total, Gg N_2O	Total, Gg CO_2eq
1990	0.515	0.041	0.006	0	0.016	0	0.009	0.022	0.609	**0.96**	**297**
1991	0.481	0.034	0.005	0	0.014	0	0.007	0.020	0.563	**0.88**	**274**
1992	0.399	0.022	0.004	0	0.012	0	0.005	0.011	0.453	**0.71**	**221**
1993	0.371	0.017	0.004	0	0.009	0	0.004	0.012	0.418	**0.66**	**204**
1994	0.380	0.017	0.004	0	0.008	0	0.004	0.012	0.425	**0.67**	**207**
1995	0.392	0.016	0.004	0	0.007	0	0.003	0.014	0.438	**0.69**	**213**
1996	0.407	0.015	0.004	0	0.006	0	0.003	0.015	0.452	**0.71**	**220**
1997	0.416	0.015	0.005	0	0.005	0	0.003	0.016	0.461	**0.72**	**224**
1998	0.427	0.017	0.005	0	0.005	0	0.004	0.008	0.466	**0.73**	**227**
1999	0.457	0.019	0.005	0	0.006	0	0.004	0.009	0.500	**0.79**	**244**
2000	0.481	0.021	0.005	0	0.006	0	0.004	0.008	0.525	**0.82**	**256**
2001	0.482	0.021	0.005	0	0.006	0	0.004	0.009	0.528	**0.83**	**257**
2002	0.499	0.021	0.005	0	0.006	0	0.004	0.009	0.545	**0.86**	**265**
2003	0.511	0.022	0.006	0	0.006	0	0.005	0.009	0.559	**0.88**	**272**

Year	Drylot		Other systems								
	Cattle 3.B.2.1	Swine 3.B.2.6	Cattle 3.B.2.1	Buffalos 3.B.2.2	Sheep 3.B.2.3	Goats 3.B.2.4	Swine 3.B.2.6	Poultry 3.B.2.7	Total, Gg N_N2O	Total, Gg N_2O	Total, Gg CO_2eq
2004	0.484	0.022	0.005	0	0.007	0	0.005	0.010	0.535	**0.84**	**260**
2005	0.492	0.021	0.005	0	0.007	0	0.004	0.008	0.538	**0.85**	**262**
2006	0.446	0.016	0.005	0	0.007	0	0.003	0.005	0.483	**0.76**	**235**
2007	0.435	0.005	0.005	0	0.007	0	0.001	0.006	0.460	**0.72**	**224**
2008	0.448	0.004	0.005	0	0.007	0	0.001	0.007	0.472	**0.74**	**230**
2009	0.427	0.006	0.005	0	0.006	0	0.001	0.007	0.453	**0.71**	**220**
2010	0.447	0.005	0.005	0	0.006	0	0.001	0.007	0.471	**0.74**	**229**
2011	0.444	0.005	0.005	0	0.006	0	0.001	0.006	0.468	**0.73**	**228**
2012	0.471	0.009	0.005	0	0.007	0	0.002	0.006	0.501	**0.79**	**244**
2013	0.503	0.009	0.005	0	0.008	0	0.002	0.007	0.535	**0.84**	**261**
2014	0.546	0.008	0.006	0	0.009	0	0.002	0.007	0.577	**0.91**	**281**
2015	0.569	0.007	0.006	0	0.009	0	0.002	0.008	0.601	**0.94**	**293**
2016	0.578	0.006	0.006	0	0.009	0	0.001	0.008	0.609	**0.96**	**297**
2017	0.544	0.007	0.006	0	0.009	0	0.001	0.008	0.576	**0.90**	**280**

4.12.2.2. Indirect N_2O emissions from Manure Management

Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia (NH_3) and nitrogen oxides (NO_x). Nitrogen losses begin at the point of excretion in housings and other animal production areas.

Methodology:
Tier 1 method is used. Calculation of N volatilization in forms of NH_3 and NO_x from manure management systems implies multiplication of the amount of nitrogen excreted (from all livestock categories) and managed in each manure management system by a fraction of volatilized nitrogen (IPCC 2006, Chapter 10, Equation 10.26). N losses are then summed over all manure management systems. The Tier 1 method is applied using nitrogen excretion data from *Table 4-69* and manure management system data from *Table 4-70*.

According to the IPCC 2006, due to extremely limited measurement data on leaching and runoff losses from various manure management systems, “estimation of N losses from leaching and runoff from manure management should be considered part of a Tier 2 or Tier 3 method”.

N losses due to volatilization from manure management are estimated using formula

$$N_{volatilization-MMS} = \sum_S \left[\sum_T \left[\left(N_{(T)} \times Nex_{(T)} \times MS_{(T,S)} \right) \times \left(\frac{Frac_{GaMS}}{100} \right)_{(T,S)} \right] \right]$$

Where:

$N_{volatilization\text{-}MMs}$ amount of manure nitrogen that is lost due to volatilization of NH3 and NOx, kg N/year

$N_{(T)}$ 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, kgN/animal/year

$MS_{(T,S)}$ fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, 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, %

$$N_2O_{G(mm)} = (N_{volatilization\text{-}MMs} \times EF_4) \times 44/28$$

Where:

$N_2O_{G(mm)}$	indirect N_2O emissions due to volatilization of N from Manure Management in the country, kg N_2O/year
EF_4	emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces, kg N_2O-N (kg NH_3-N + NO_x-N volatilized).

Activity data:
Animal population data and distribution by categories are obtained from *Table 4-54* and *Table 4-66*.

Emission factors:
$Nex_{(T)}$ and $MS_{(T,S)}$ are presented respectively in tables 4.25 and 4.26. For EF_4 default value 0.01 kg N_2O–N (kg NH_3–N + NO_x–N volatilized) is used [IPCC 2006, Chapter 11, p.11.24, Table 11.3]. $Frac_{GasMS}$ = 0.2 [IPCC 2006, Chapter 11, p.11.24, Table 11.3]. Default values of fractions of N losses from manure management systems due to volatilization are used (IPCC 2006, Chapter 10, p. 10.65, Table 10.22).

Emissions.
Indirect N_2O Emissions from different manure management systems are given in *Table 4-73*.

Table 4-73 Indirect N_2O emissions (in Gg) from Manure Management

Year	Drylot		Other systems								
	Cattle 3.B.2.1	Swine 3.B.2.6	Cattle 3.B.2.1	Buffalos 3.B.2.2	Sheep 3.B.2.3	Goats 3.B.2.4	Swine 3.B.2.6	Poultry 3.B.2.7	Total, Gg N_N2O	Total	Total, in Gg CO_2eq
1990	0.103	0.010	0.004	0	0.008	0	0.009	0.004	0.139	0.22	68
1991	0.096	0.008	0.004	0	0.007	0	0.007	0.004	0.128	0.20	62
1992	0.080	0.006	0.003	0	0.006	0	0.005	0.002	0.102	0.16	50
1993	0.074	0.004	0.003	0	0.005	0	0.004	0.002	0.093	0.15	45
1994	0.076	0.004	0.003	0	0.004	0	0.004	0.002	0.094	0.15	46
1995	0.078	0.004	0.003	0	0.003	0	0.003	0.003	0.096	0.15	47
1996	0.081	0.004	0.004	0	0.003	0	0.003	0.003	0.098	0.15	48
1997	0.083	0.004	0.004	0	0.003	0	0.003	0.003	0.100	0.16	49
1998	0.085	0.004	0.004	0	0.003	0	0.004	0.002	0.101	0.16	49
1999	0.091	0.005	0.004	0	0.003	0	0.004	0.002	0.109	0.17	53
2000	0.096	0.005	0.004	0	0.003	0	0.004	0.002	0.114	0.18	56
2001	0.096	0.005	0.004	0	0.003	0	0.004	0.002	0.115	0.18	56
2002	0.100	0.005	0.004	0	0.003	0	0.004	0.002	0.119	0.19	58
2003	0.102	0.005	0.004	0	0.003	0	0.005	0.002	0.122	0.19	59
2004	0.097	0.006	0.004	0	0.004	0	0.005	0.002	0.117	0.180	57
2005	0.098	0.005	0.004	0	0.004	0	0.004	0.002	0.118	0.185	57
2006	0.089	0.004	0.004	0	0.004	0	0.003	0.001	0.105	0.170	51
2007	0.087	0.001	0.004	0	0.004	0	0.001	0.001	0.098	0.154	48
2008	0.090	0.001	0.004	0	0.004	0	0.001	0.001	0.100	0.160	49
2009	0.085	0.002	0.004	0	0.003	0	0.001	0.001	0.097	0.152	47
2010	0.089	0.001	0.004	0	0.003	0	0.001	0.001	0.100	0.157	49
2011	0.089	0.001	0.004	0	0.003	0	0.001	0.001	0.099	0.156	48
2012	0.094	0.002	0.004	0	0.003	0	0.002	0.001	0.108	0.170	52
2013	0.101	0.002	0.004	0	0.004	0	0.002	0.001	0.115	0.180	56
2014	0.109	0.002	0.005	0	0.004	0	0.002	0.001	0.123	0.194	60
2015	0.114	0.002	0.005	0	0.004	0	0.002	0.002	0.128	0.200	62
2016	0.116	0.002	0.005	0	0.004	0	0.001	0.002	0.130	0.200	63
2017	0.109	0.002	0.005	0	0.004	0	0.001	0.002	0.123	0.190	60

4.12.2.3. Other

Not occurring (NO)

4.13. Rice Cultivation (3.C.)

Rice is not cultivated in Georgia (NO).

4.14. Agricultural Soils (3.D.)

Nitrous oxide emissions from agricultural soils consist of direct and indirect sources. Direct source emissions result from nitrogen that has entered the soil from synthetic fertilizer, nitrogen from animal manure, nitrogen from crop residue decomposition and nitrogen deposited by grazing animals on fields (pasture range and paddock). Emissions from indirect sources are emitted off site through volatilization and leaching of synthetic fertilizer and manure nitrogen.

4.14.1. Direct Soil Emissions (3.D.a.)

N_2O direct emissions from soils (kg N/year) are calculated by the following formula:

$$N_2O_{Direct} - N = N_2O - N_{N\ inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

$$N_2O - N_{Ninput} = \begin{bmatrix} [(F_{SN+}F_{ON} + F_{CR} + F_{SOM}) \times EF_1] + \\ [(F_{SN} + F_{ON} + F_{CR} + F_{SOM})_{FR} \times EF_{1FR}] \end{bmatrix}$$

$$N_2O - N_{OS} = \begin{bmatrix} (F_{OS,CG,Temp} \times EF_{2CG,Temp}) + (F_{OS,CG,Trop} \times EF_{2CG,Trop}) + \\ (F_{OS,F,Temp,NR} \times EF_{2F,Temp,NR}) + (F_{OS,F,Temp,NP} \times EF_{2F,Temp,NP}) + \\ (F_{OS,F,Trop} \times \mathrm{EF}_{\mathrm{2F,Trop}}) \end{bmatrix}$$

$$N_2O - N_{PRP} = [(F_{PRP,CPP} \times EF_{3PRP,CPP}) + (F_{PRP,SO} \times EF_{3PRP,SO})]$$

Notes:

The subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor respectively;
The subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and other animals, respectively;
The subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and other animals, respectively;

Where:

N_2O_{Direct} –N	annual direct N_2O–N emissions produced from managed soils, kg N_2O–N/year
N_2O–$N_{N\ inputs}$	annual direct N_2O–N emissions from N inputs to managed soils, kg N_2O–N/year
N_2O–N_{OS}	annual direct N_2O–N emissions from managed organic soils, kg N_2O–N/year
N_2O–N_{PRP}	annual direct N_2O–N emissions from urine and dung inputs to grazed soils, kgN_2O–N/year
F_{SN}	annual amount of synthetic fertilizer N applied to soils, kg N/year
F_{ON}	annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N/year
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/year
F_{SOM}	annual amount of N in mineral soils that is mineralized, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kgN/year
F_{OS}	annual area of managed/drained organic soils, ha
F_{PRP}	annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N/year
EF_1	emission factor for N_2O emissions from N inputs, kg N_2O–N/(kg N input)
EF_{1FR}	emission factor for N_2O emissions from N inputs to flooded rice, kg N_2O–N/(kg N input)

EF_2	emission factor for N_2O emissions from drained/managed organic soils, kg N_2O – N/ha/year
$EF3_{PRP}$	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)

4.14.1.1. Inorganic N Fertilizers (3.D.a.1.)

Synthetic fertilizers add large quantities of nitrogen to agricultural soils. This added nitrogen undergoes nitrification and denitrification, and releases N_2O. Emission rates associated with fertilizer application will depend on many factors such as the quantity and type of nitrogen fertilizers, crop types, soil types, climate, and other environmental conditions.

Methodology:
Tier 1 approach is used. N_2O emissions are calculated by multiplying fertilizer consumption by the non-volatilized fraction (available for nitrification and denitrification) and by an emission factor:

$$N_2O_{SN} = F_{SN} \times EF_1$$

Where:

F_{SN}	annual amount of synthetic fertilizer N applied to soils, kg N/year
EF_1	emission factor for N_2O emissions from N inputs, kg N_2O–N/kg N input

According to the IPCC 2006, for the Tier 1 approach, the amount of applied mineral nitrogen fertilizer is not adjusted for the amounts of NH_3 and NO_x volatilization after application to soil. This is different from the methodology described in the 1996 IPCC Guidelines.

Activity data:
Data on synthetic N fertilizers applied to soil are provided by the National Statistics Office of Georgia. Data on Synthetic N fertilizers applied to soil is presented in *Table 4-74*.

Emission factor:
The IPCC default emission factor EF_1=0.0125 kgN_2O-N/kgN is used (IPCC GPG, p.4.60, table 4.17).

Emissions:
N_2O emissions from synthetic N fertilizers applied to soil are presented in *Table 4-74*.

Table 4-74 N_2O Direct emissions from synthetic N fertilizers applied to soils in 2004-2017 years

Year	Synthetic fertilizer N applied, Gg	Amount of N input, Gg N	Emission, Gg N_2O	Emission in Gg CO_2-eq
1990	60.8	0.76	1.19	370
1991	49.8	0.62	0.98	303
1992	45.9	0.57	0.90	279
1993	45.7	0.57	0.90	278
1994	31.1	0.39	0.61	189
1995	38.6	0.48	0.76	235
1996	84.3	1.05	1.66	513
1997	95.2	1.19	1.87	580
1998	61.7	0.77	1.21	376
1999	79.2	0.99	1.56	482

Year	Synthetic fertilizer N applied, Gg	Amount of N input, Gg N	Emission, Gg N_2O	Emission in Gg CO_2-eq
2004	47.7	0.60	0.94	290
2005	46.2	0.58	0.91	281
2006	67.2	0.84	1.32	409
2007	46.8	0.59	0.92	285
2008	51.2	0.64	1.01	312
2009	57.7	0.72	1.13	351
2010	50.2	0.63	0.99	306
2011	43.3	0.54	0.85	264
2012	49.5	0.62	0.97	301
2013	64.6	0.81	1.27	393

2000	47.5	0.59	0.93	289	2014	50.8	0.64	1.00	309
2001	57.3	0.72	1.13	349	2015	49.9	0.62	0.98	304
2002	72.8	0.91	1.43	443	2016	51.0	0.64	1.00	311
2003	75.8	0.95	1.49	462	2017	39.7	0.50	0.78	242

4.14.1.2. Organic Fertilizer (3.D.a.2.)

Organic N fertilizer includes applied animal manure, sewage sludge, compost and other organic amendments applied to soils. The application of organic N fertilizers to soils can increase the rate of nitrification and denitrification and result in enhanced N_2O emissions from agricultural soils. As a rule, all the manure from manure management systems is applied to agricultural soils. Manure deposited on land by grazing animals is considered separately.

Methodology:
Emissions are calculated by multiplying the amount of organic nitrogen applied to agricultural soils by the non-volatilized fraction by an emission factor:

$$N_2O_{ON} = F_{ON} \times EF_1$$

$$F_{ON} = F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$$

Where:

F_{ON} = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils, kgN/year

EF_1 = emission factor for N_2O emissions from N inputs, kg N_2O–N/kg N input

F_{AM} = annual amount of animal manure N applied to soils, kg N/year

F_{SEW} = annual amount of total sewage N that is applied to soils, kg N/year

F_{COMP} = annual amount of total compost N applied to soils, kg N/year

F_{OOA} = annual amount of other organic amendments used as fertilizer (e.g., rendering waste, guano, brewery waste, etc.), kg N/year

In Georgia sewage, compost and other organic amendments practically/actually are not used as N fertilizer. Consequently, F_{SEW}, F_{COMP} and F_{OOA} are not considered.

For calculating annual amount of animal manure applied to soils the following formula is used:

$$F_{AM} = N_{MMSAvb} \times [1 - (Frac_{FEED} + Frac_{FUEL} + Frac_{CNST})]$$

Where:

F_{AM} = annual amount of animal manure N applied to soils, kg N/year

$N_{MMS\,Avb}$ = amount of managed manure N available for soil application, feed, fuel or construction, kgN/year

$Frac_{FEED}$ = 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

In Georgia, only insignificant amount of manure is used as fuel, and none of it is used for feed and construction purposes.

The estimate of managed manure nitrogen available for application to managed soils is based on the following equation:

$$N_{MMS\_Avb} = \sum_{(S)} \left\{ \sum_{(T)} \left[\left(N_{(T)} \times Nex_{(T)} \times MS_{(T,S)}\right) \times \left(1 - \frac{Frac_{lossMS}}{100}\right) \right] \right\}$$

Where:

$N_{(T)}$	number of head of livestock species/category T in the country
$Nex_{(T)}$	annual average N excretion per animal of species/category T in the country, kgN/animal/year
$MS_{(T,S)}$	fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless
$Frac_{LossMS}$	amount of managed manure nitrogen for livestock category T that is lost in the manure management system S, %
S	manure management system
T	species/category of livestock

According to the IPCC 2006, for the Tier 1 approach, the amount of applied organic nitrogen fertilizers is not adjusted for the amounts of NH_3 and NO_x volatilization after application to soil. This is a difference from the methodology described in the 1996 IPCC Guidelines.

Activity data: The animal population data are the same as those used for the Enteric Fermentation estimates (*Table 4-54*, *Table 4-66*).

Emission factor:

The IPCC 2006 default emission factor EF_1=0.0125 kgN_2O-N/kgN (IPCC GPG, p.4.60, table 4.17) and default values of parameter $Frac_{LossMS}$ are used [IPCC 2006, Chapter 10, p.10.67, Table 10.23]. Nitrogen Excretion rate (Nex) for animal types are presented in *Table 4-69.*

Calculated Emissions:

Estimated nitrous oxide emissions from Organic N fertilizers applied to soil are presented in *Table 4-75*.

Table 4-75 Estimated nitrous oxide emissions (in Gg) from manure applied to soil in years 1990-2017

Year	Dry lot		Other systems										
	Cattle 3.B.2.1	Swine 3.B.2.6	Cattle 3.B.2.1	Buffalos 3.B.2.2	Sheep 3.B.2.3	Goats 3.B.2.4	Swine 3.B.2.6	Horses	Assess	Poultry 3.B.2.7	Total, Gg N	Total, Gg N_2O	Total, Gg CO_2eq
1990	0.193	0.018	0.008	0.001	0.030	0.0005	0.015	0.0004	NE	0.022	0.288	0.45	140
1991	0.18	0.015	0.008	0.001	0.027	0.0004	0.013	0.0003	NE	0.02	0.264	0.42	129
1992	0.15	0.01	0.007	0.001	0.022	0.0003	0.008	0.0003	NE	0.011	0.208	0.33	102
1993	0.139	0.007	0.006	0.001	0.018	0.0003	0.006	0.0004	NE	0.012	0.190	0.30	92
1994	0.142	0.007	0.006	0.0005	0.014	0.0003	0.006	0.0004	NE	0.012	0.190	0.30	93
1995	0.147	0.007	0.006	0.0005	0.013	0.0004	0.006	0.0004	NE	0.014	0.195	0.31	95
1996	0.153	0.007	0.007	0.0005	0.011	0.0004	0.006	0.0005	NE	0.015	0.199	0.31	97
1997	0.156	0.007	0.007	0.0005	0.010	0.0004	0.006	0.001	0.0001	0.016	0.202	0.32	99
1998	0.160	0.007	0.007	0.0005	0.010	0.0005	0.006	0.001	0.0001	0.008	0.201	0.32	98
1999	0.171	0.008	0.007	0.0005	0.011	0.001	0.007	0.001	0.0001	0.009	0.215	0.34	105
2000	0.180	0.009	0.008	0.0005	0.010	0.001	0.008	0.001	NE	0.008	0.225	0.35	109
2001	0.181	0.009	0.008	0.001	0.011	0.001	0.008	0.001	0.0001	0.009	0.227	0.36	111
2002	0.187	0.009	0.008	0.0005	0.012	0.001	0.008	0.001	NE	0.009	0.234	0.37	114
2003	0.191	0.010	0.008	0.001	0.012	0.001	0.008	0.001	NE	0.009	0.241	0.38	117
2004	0.182	0.010	0.008	0.001	0.013	0.001	0.008	0.001	0.0001	0.010	0.233	0.37	114
2005	0.184	0.009	0.008	0.0005	0.014	0.001	0.008	0.001	0.0001	0.008	0.233	0.37	113
2006	0.167	0.007	0.007	0.0005	0.013	0.001	0.006	0.0005	0.0001	0.005	0.208	0.33	101
2007	0.163	0.002	0.007	0.0004	0.014	0.001	0.002	0.0004	0.0001	0.006	0.195	0.31	95
2008	0.168	0.002	0.007	0.0004	0.013	0.001	0.001	0.001	0.0001	0.007	0.200	0.31	97
2009	0.160	0.003	0.007	0.0004	0.011	0.001	0.002	0.001	0.0001	0.007	0.192	0.30	93

Year	Dry lot		Other systems										
	Cattle 3.B.2.1	Swine 3.B.2.6	Cattle 3.B.2.1	Buffalos 3.B.2.2	Sheep 3.B.2.3	Goats 3.B.2.4	Swine 3.B.2.6	Horses	Assess	Poultry 3.B.2.7	Total, Gg N	Total, Gg N_2O	Total, Gg CO_2eq
2010	0.168	0.002	0.007	0.0004	0.011	0.0004	0.002	0.001	0.0001	0.007	0.198	0.31	97
2011	0.167	0.002	0.007	0.0004	0.011	0.0004	0.002	0.001	0.0001	0.006	0.197	0.31	96
2012	0.177	0.004	0.008	0.0004	0.013	0.0004	0.004	0.001	0.0001	0.006	0.213	0.33	104
2013	0.189	0.004	0.008	0.0004	0.015	0.0004	0.003	0.001	0.0001	0.007	0.228	0.36	111
2014	0.205	0.003	0.009	0.0002	0.017	0.0004	0.003	0.001	0.0001	0.007	0.244	0.38	119
2015	0.213	0.003	0.009	0.0003	0.016	0.0004	0.003	0.001	0.0004	0.008	0.254	0.40	124
2016	0.217	0.003	0.009	0.0003	0.017	0.0004	0.002	0.0004	0.0004	0.008	0.257	0.40	125
2017	0.204	0.003	0.009	0.0003	0.016	0.0004	0.003	0.0004	0.0003	0.008	0.244	0.38	119

4.14.1.3. Urine and dung deposited by grazing animals (3.D.a.3.)

Emissions from manure dropped on the soil during grazing on grasslands are reported under this subcategory. When manure is excreted on pasture and paddock from grazing animals, nitrogen in the manure undergoes transformations. During these transformation processes, N_2O is produced.

Methodology:
The annual amount of N_2O from Urine and dung from grazing animals are calculated for each animal category by multiplying the animal population by the appropriate nitrogen excretion rate and by the fraction of manure nitrogen available for conversion to N_2O.

Methodology is based on the following formulas:

$$N_2O - N_{PRP} = \left[\left(F_{PRP,CPP} \times EF_{3PRP,CPP}\right) + \left(F_{PRP,SO} \times EF_{3PRP,SO}\right)\right]$$

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

Where:

EF_{3PRP} = emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, kg N_2O–N/(kg N input). The subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and other animals, respectively.

F_{PRP} = annual amount of urine and dung N deposited on pasture, range and paddock by grazing animals, kgN/year

$N_{(T)}$ = 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/year

$MS_{(T,PRP)}$ = fraction of total annual N excretion for each livestock species/category T that is deposited on pasture, range and paddock

T = type of animal category.

Activity data:
The animal population data are the same as those used in the Enteric Fermentation emission estimates (*Table 4-54* and *Table 4-66*). The average annual nitrogen excretion rates for domestic animals are taken from the *Table 4-69*. Fraction of total annual N excretion for each livestock species/category T that is deposited on pasture, range and paddock is given in *Table 4-70*.

Emission factors:

The default value for EF_{3PRP} is 0.02 of the N deposited by all animal types except sheep [IPCC 2006, Chapter 11, p.11.11, Table 11.1].

Emissions:
N_2O emissions from urine and dung N deposited on pastures and paddocks are given in *Table 4-76*.

Table 4-76 N_2O emissions from urine and dung N deposited on pastures and paddocks in 1990-2017

Year	kg N_2O-N									Gg N_2O in total	Gg CO2eq
	Cattle	Buffalo	Swine	Poultry	Sheeps	Goats	Horses	Assess	Total		
1990	0.56	0.03	0.04	0.07	0.31	0.02	0.01	NE	**1.04**	**1.64**	**508**
1991	0.52	0.03	0.03	0.06	0.28	0.02	0.01	NE	**0.96**	**1.51**	**467**
1992	0.43	0.03	0.02	0.04	0.23	0.01	0.01	NE	**0.77**	**1.21**	**375**
1993	0.40	0.02	0.02	0.04	0.18	0.01	0.01	NE	**0.69**	**1.08**	**335**
1994	0.41	0.02	0.02	0.04	0.15	0.01	0.02	NE	**0.66**	**1.04**	**324**
1995	0.43	0.02	0.02	0.04	0.13	0.01	0.02	NE	**0.67**	**1.06**	**327**
1996	0.44	0.02	0.02	0.05	0.12	0.01	0.02	NE	**0.68**	**1.06**	**330**
1997	0.45	0.02	0.02	0.05	0.10	0.02	0.02	0.004	**0.68**	**1.07**	**330**
1998	0.46	0.02	0.02	0.03	0.10	0.02	0.02	0.005	**0.67**	**1.05**	**327**
1999	0.50	0.02	0.02	0.03	0.11	0.02	0.03	0.005	**0.72**	**1.13**	**351**
2000	0.52	0.02	0.02	0.02	0.11	0.02	0.03	NE	**0.75**	**1.17**	**363**
2001	0.52	0.02	0.02	0.03	0.11	0.03	0.03	0.001	**0.76**	**1.20**	**371**
2002	0.54	0.02	0.02	0.03	0.12	0.03	0.03	NE	**0.79**	**1.24**	**385**
2003	0.55	0.02	0.02	0.03	0.12	0.03	0.03	NE	**0.81**	**1.27**	**395**
2004	0.53	0.02	0.02	0.03	0.14	0.03	0.03	0.01	**0.8**	**1.26**	**392**
2005	0.53	0.02	0.02	0.02	0.14	0.03	0.03	0.01	**0.8**	**1.26**	**390**
2006	0.48	0.02	0.02	0.02	0.14	0.03	0.02	0.003	**0.72**	**1.13**	**351**
2007	0.47	0.02	0.01	0.02	0.14	0.02	0.02	0.004	**0.7**	**1.09**	**339**
2008	0.49	0.02	0.004	0.02	0.14	0.02	0.02	0.003	**0.71**	**1.11**	**345**
2009	0.46	0.02	0.01	0.02	0.12	0.02	0.02	0.003	**0.67**	**1.05**	**326**
2010	0.49	0.01	0.01	0.02	0.12	0.02	0.02	0.005	**0.68**	**1.07**	**333**
2011	0.48	0.01	0.005	0.02	0.11	0.02	0.02	0.003	**0.67**	**1.06**	**328**
2012	0.51	0.01	0.01	0.02	0.14	0.02	0.02	0.002	**0.73**	**1.15**	**356**
2013	0.55	0.02	0.01	0.02	0.16	0.02	0.02	0.003	**0.79**	**1.24**	**385**
2014	0.59	0.01	0.01	0.02	0.17	0.02	0.02	0.003	**0.84**	**1.32**	**410**
2015	0.62	0.01	0.01	0.03	0.17	0.01	0.03	0.002	**0.87**	**1.37**	**425**
2016	0.63	0.01	0.01	0.03	0.17	0.02	0.02	0.002	**0.88**	**1.39**	**430**
2017	0.59	0.01	0.01	0.03	0.17	0.01	0.02	0.001	**0.84**	**1.32**	**408**

4.14.1.4. Crop Residues (3.D.a.4.)

After harvesting, part of agricultural crop residues is left in the field and decomposed. They represent nitrogen source. As a result of transformation nitrous oxide is formed.

Methodology:
Georgia uses the IPCC 2006 Tier 1 methodology for emission calculation. Annual amount of N in crop residues, F_{CR}, the sum of the above-and below-ground N contents, is provided by the Equation:

$$N_2O\text{-}N_{N\,inputs} = F_{CR} \times EF_1$$

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

Where:

F_{CR} annual amount of nitrogen in crop residues (above and below ground), including N-fixing crops,as well as from forage/pasture renewal, returned to soils annually, kg N/year

EF_1 emission factor for N_2O emissions from N inputs, kg N_2O–N /(kg N inputs)

$Crop_{(T)}$ harvested annual dry matter yield for crop T, kg d.m./ha.

$$Crop_{(T)} = Yield\ Fresh_{(T)} \times DRY$$

$Crop_{(T)} = Yield\ Fresh_{(T)} \times DRY$
$Yield\_Fresh_{(T)}$ = harvested fresh yield for crop T, kg fresh weight/ha
DRY = dry matter fraction of harvested crop T, kg d.m./(kg fresh weight)
$Area_{(T)}$ = total annual area harvested of crop T, ha/year
$Area\ burnt_{(T)}$ = annual area of crop T burnt, ha/year
C_f = combustion factor (dimensionless)
$Frac_{Renew(T)}$ = fraction of total area under crop T that is renewed annually
$R_{AG(T)}$ = ratio of above-ground residues dry matter ($A_{GDM(T)}$) to harvested yield ($Crop_{(T)}$), kgd.m./(kg d.m.)
$R_{AG(T)} = A_{GDM(T)} \times 1000 / Crop_{(T)}$;
$A_{GDM(T)} = (Crop_{(T)}/1000) \times slope_{(T)} + intercept_{(T)}$
$N_{AG(T)}$ = N content of above-ground residues for crop T, kg N/(kg d.m.)
$Frac_{Remove(T)}$ = fraction of above-ground residues of crop T removed annually for purposes such as feed, bedding and construction, kg N/(kg crop-N).
$R_{BG(T)}$ = ratio of below-ground residues to harvested yield for crop T, kg d.m./kg d.m.
$R_{BG(T)} = R_{BG-BIO(T)} \times [(A_{GDM(T)} \times 1000 + Crop_{(T)}) / Crop_{(T)}]$
$N_{BG(T)}$ = N content of below-ground residues for crop T, kg N/kg d.m.
T = crop or forage type

Activity data:
Data on agriculture crop production are provided by The National Statistics Office of Georgia.

Emission factors:
For emission factor IPCC GDP default value is used - EF_1=0.0125 kg(N_2O-N)/(kgN inputs). For annual crops $Frac_{Renew}$ = 1. Data for $Frac_{Remove}$ are not available in Georgia, therefore, $Frac_{Remove(T)}$ = 0. Other input factors used for estimation of N from crop residues added to soils are used according to the IPCC 2006 [IPCC 2006, Chapter 11, P.11.17, table 11.2, Chapter 2, p.2.49, table 2.6].

Table 4-77 Input factors used for estimation of N from crop residues added to soils

Crop	Dry matter fraction of harvested crop DRY, kg d.m./ kg fresh weight	N content of above-ground residues NAG , kg N/kg d.m.	Ratio of belowground residues to above-ground biomass RBG-BIO , kg d.m./kg d.m.	N in below-ground residues NBG , kgN/kg d.m	Slope	Intercept	Combustion factor CF
Wheat	0.89	0.006	0.24	0.009	1.51	0.52	0.9
Barley	0.89	0.007	0.22	0.014	0.98	0.59	0.9
Maize	0.87	0.006	0.22	0.007	1.03	0.61	0.8
Oats	0.89	0.007	0.25	0.008	0.91	0.89	0.8
Potatoes	0.22	0.019	0.20	0.014	0.10	1.06	0.8
Dry Beans	0.9	0.01	0.19	0.01	1.36	0.68	0.8

Emissions: N_2O emissions from crop residue decomposition are given in *Table 4-78*.

Table 4-78 N_2O emissions from crop residue decomposition

Year	GHG emission		Year	GHG emission	
	Gg N_2O	in Gg CO_2-eq		Gg N_2O	in Gg CO_2-eq
1990	0.20	62	2004	0.16	50
1991	0.17	52	2005	0.21	65

Year	GHG emission		Year	GHG emission	
	Gg N_2O	in Gg CO_2-eq		Gg N_2O	in Gg CO_2-eq
1992	0.14	45	2006	0.08	25
1993	0.11	35	2007	0.10	30
1994	0.13	40	2008	0.10	31
1995	0.12	36	2009	0.09	27
1996	0.14	45	2010	0.07	22
1997	0.21	66	2011	0.11	34
1998	0.16	49	2012	0.11	33
1999	0.19	58	2013	0.13	41
2000	0.13	41	2014	0.11	35
2001	0.17	54	2015	0.12	38
2002	0.17	51	2016	0.12	36
2003	0.18	57	2017	0.09	27

Table 4-79 Direct N_2O emissions from soils

Year	Source				Total	
	Synthetic N fertilizers	Organic N fertilizers	Urine and dung deposition	Crop residues decomposition	GgN_2O	GgCO_2eq
1990	1.19	0.45	1.64	0.20	3.49	1,080
1991	0.98	0.42	1.51	0.17	3.07	951
1992	0.90	0.33	1.21	0.14	2.58	801
1993	0.90	0.30	1.08	0.11	2.39	740
1994	0.61	0.30	1.04	0.13	2.08	645
1995	0.76	0.31	1.06	0.12	2.24	694
1996	1.66	0.31	1.06	0.14	3.18	985
1997	1.87	0.32	1.07	0.21	3.47	1,075
1998	1.21	0.32	1.05	0.16	2.74	850
1999	1.56	0.34	1.13	0.19	3.21	997
2000	0.93	0.35	1.17	0.13	2.59	803
2001	1.13	0.36	1.20	0.17	2.85	884
2002	1.43	0.37	1.24	0.17	3.21	994
2003	1.49	0.38	1.27	0.18	3.33	1,031
2004	0.94	0.37	1.26	0.16	2.73	846
2005	0.91	0.37	1.26	0.21	2.74	849
2006	1.32	0.33	1.13	0.08	2.86	887
2007	0.92	0.31	1.09	0.10	2.42	749
2008	1.01	0.31	1.11	0.10	2.54	786
2009	1.13	0.30	1.05	0.09	2.57	798
2010	0.99	0.31	1.07	0.07	2.44	757
2011	0.85	0.31	1.06	0.11	2.33	722
2012	0.97	0.33	1.15	0.11	2.56	794
2013	1.27	0.36	1.24	0.13	3.00	931
2014	1.00	0.38	1.32	0.11	2.82	874
2015	0.98	0.40	1.37	0.12	2.87	891
2016	1.00	0.40	1.39	0.12	2.91	902
2017	0.78	0.38	1.32	0.09	2.57	796

4.14.2. Indirect Emissions (3.D.b.)

A fraction of the fertilizer nitrogen (from synthetic and organic N fertilizers and urine and dung deposition from grazing animals) that is applied to agricultural fields will be removed off-site either through volatilization and subsequent re-deposition or leaching, erosion and runoff. The nitrogen that is transported from the agricultural field in this manner will provide additional nitrogen for subsequent nitrification and denitrification to produce N_2O. The nitrogen leaving an agricultural field may not be available for the process of nitrification and denitrification for many years, particularly in the case of nitrogen leaching into groundwater.

4.14.2.1. Atmospheric Deposition (3.D.b.1.)

Methodology:
IPCC 2006 Tier 1 methodology is used to estimate indirect N_2O emissions due to volatilization and re-deposition of nitrogen from applied to soil N.

The N_2O emissions from atmospheric deposition of N volatilized from managed soil are estimated using the following Equation:

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

Where:

$N_2O_{(ATD)}$	annual amount of N_2O–N produced from atmospheric deposition of N volatilized from managed soils, kg N_2O–N/year
F_{SN}	annual amount of synthetic fertilizer N applied to soils, kg N/year
$Frac_{GASF}$	fraction of synthetic fertilizer N that volatilizes as NH_3 and NO_x, kg N volatilized/(kg N applied)
F_{ON}	annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N/year
F_{PRP}	annual amount of urine and dung N deposited by grazing animals on pasture range and paddock, kgN/year
$Frac_{GASM}$	fraction of applied organic N fertilizer materials (F_{ON}) and of urine and dung N Deposited by grazing animals (F_{PRP}) that volatilizes as NH_3 and NO_x, (kg N volatilized)/(kg of N applied or deposited)
$N_2O_{(ATD)}$	$N_2O_{(ATD)}$–N × 44/28

Activity data:
The data on amount of N fertilizers is obtained from the State Statistics Office of Georgia.

Emission factors:
The IPCC 2006 default emission factor is applied to derive the N_2O emission estimate, EF_4 =0.01 kg(N_2O-N)/kgN [IPCC 2006, Chapter 11, p. 11.24, table 11.3).

$Frac_{GASF}$ = 0.10 (kg N volatilized)/(kg N applied) and $Frac_{GASM}$ = 0.2 (kg NH3–N + NOx–N)/(kg N applied) [IPCC 2006, Chapter 11, p. 11.24, table 11.3).

Emissions:
Estimated GHG emissions are presented in *Table 4-80*

Table 4-80 Estimated N_2O emissions from volatilization and re-deposition in 1990–2017

Year	F_{SN}	$Frac_{GASF}$	F_{ON}	F_{PRP}	$Frac_{GASM}$	EF_4	$N_2O_{(ATD)}$–N	Gg N_2O	Gg CO_2eq
1990	61	0.1	23	52	0.2	0.1	0.211	**0.332**	**103**
1991	50	0.1	21	48	0.2	0.1	0.188	**0.295**	**92**
1992	46	0.1	17	38	0.2	0.1	0.156	**0.245**	**76**
1993	46	0.1	15	34	0.2	0.1	0.145	**0.228**	**71**
1994	31	0.1	15	33	0.2	0.1	0.128	**0.201**	**62**
1995	39	0.1	16	34	0.2	0.1	0.137	**0.215**	**67**
1996	84	0.1	16	34	0.2	0.1	0.184	**0.289**	**90**
1997	95	0.1	16	34	0.2	0.1	0.195	**0.307**	**95**
1998	62	0.1	16	34	0.2	0.1	0.161	**0.253**	**78**
1999	79	0.1	17	36	0.2	0.1	0.186	**0.292**	**90**
2000	48	0.1	18	37	0.2	0.1	0.158	**0.248**	**77**
2001	57	0.1	18	38	0.2	0.1	0.170	**0.267**	**83**

Year	F_{SN}	$Frac_{GASF}$	F_{ON}	F_{PRP}	$Frac_{GASM}$	EF_4	$N_2O_{(ATD)}$−N	Gg N_2O	Gg CO_2eq
2002	73	0.1	19	39	0.2	0.1	0.189	**0.297**	**92**
2003	76	0.1	19	41	0.2	0.1	0.195	**0.307**	**95**
2004	48	0.1	19	40	0.2	0.1	0.165	**0.260**	**81**
2005	46	0.1	19	40	0.2	0.1	0.163	**0.257**	**80**
2006	67	0.1	17	36	0.2	0.1	0.173	**0.271**	**84**
2007	47	0.1	16	35	0.2	0.1	0.148	**0.232**	**72**
2008	51	0.1	16	35	0.2	0.1	0.154	**0.242**	**75**
2009	58	0.1	15	33	0.2	0.1	0.155	**0.244**	**76**
2010	50	0.1	16	34	0.2	0.1	0.150	**0.236**	**73**
2011	43	0.1	16	34	0.2	0.1	0.142	**0.223**	**69**
2012	50	0.1	17	37	0.2	0.1	0.157	**0.246**	**76**
2013	65	0.1	18	40	0.2	0.1	0.180	**0.283**	**88**
2014	51	0.1	20	42	0.2	0.1	0.174	**0.273**	**85**
2015	50	0.1	20	44	0.2	0.1	0.178	**0.279**	**87**
2016	51	0.1	21	44	0.2	0.1	0.180	**0.284**	**88**
2017	40	0.1	20	42	0.2	0.1	0.163	**0.255**	**79**

4.14.2.2. Nitrogen Leaching and Run-off (3.D.b.2.)

When synthetic fertilizer or manure nitrogen is applied to cropland, a portion of this nitrogen is lost through leaching, runoff, and erosion. The quantity of this nitrogen loss depends on a number of factors, such as rates, methods and time of nitrogen application, crop type, soil texture, rainfall, landscape, etc. This portion of lost nitrogen can further undergo transformations, such as nitrification and denitrification, thus producing N_2O emissions off site.

Methodology:

The IPCC 2006 Tier 1 methodology estimates for N_2O emissions from runoff and leaching of nitrogen is used. The N_2O emissions from leaching and runoff are estimated using the following Equation:

$$N_2O_L - N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) \times Frac_{LEACH-(H)} \times EF_5$$

Where:

- $N_2O_{(L)}-N$ annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils, kg N_2O–N/year
- F_{SN} annual amount of synthetic fertilizer N applied to soils, kgN/ year
- F_{ON} annual amount of managed animal manure, compost, sewage sludge and other organic N applied to soils, kg N/year
- F_{PRP} annual amount of urine and dung N deposited by grazing animals, kg N/year
- F_{CR} amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually in regions where leaching/runoff occurs, kg N/year
- F_{SOM} annual amount of N 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, kgN/year. In Georgia N_2O emissions from this source category are occurring only on a very small scale
- $Frac_{LEACH-(H)}$ 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)
- EF_5 emission factor for N_2O emissions from N leaching and runoff, kg N N O–N (kg N leached and runoff)

Activity data:

Data on nitrogen applied are the same as used in Direct N_2O emissions from managed soil.

Emission factor:
Fraction of all N added to soils that is lost through leaching and runoff, kg N/(kg of N additions), $Frac_{LEACH-(H)}$ = 0.30 is used [IPCC 2006, Chapter 11, p.11.24, Table 11.3]. IPCC 1996 recommends default value for emission factor - EF_5 = 0.025 kg N_2O-N/(kg N leaching and runoff).. The latter one is more appropriate for conditions of Georgia.

Emissions:
N_2O emissions from Leaching and Runoff of N during 1990-2017 years period are provided in *Table 4-81*.

Table 4-81 N_2O emissions from leaching and runoff in 1990-2017 years

Year	**F_{SN}**	**F_{ON}**	**F_{PRP}**	**F_{CR}**	**$Frac_{LEACH-(H)ASM}$**	**EF_5**	**$N_2O_{(ATD)}$–N**	**Gg N_2O**	**Gg CO_2eq**
1990	61	23	52	10	0.3	0.025	1.10	**1.72**	**534**
1991	50	21	48	9	0.3	0.025	0.96	**1.50**	**466**
1992	46	17	38	7	0.3	0.025	0.81	**1.28**	**396**
1993	46	15	34	6	0.3	0.025	0.76	**1.19**	**369**
1994	31	15	33	6	0.3	0.025	0.65	**1.01**	**314**
1995	39	16	34	6	0.3	0.025	0.70	**1.11**	**343**
1996	84	16	34	7	0.3	0.025	1.06	**1.67**	**517**
1997	95	16	34	11	0.3	0.025	1.17	**1.84**	**571**
1998	62	16	34	8	0.3	0.025	0.90	**1.41**	**436**
1999	79	17	36	10	0.3	0.025	1.07	**1.67**	**519**
2000	48	18	37	7	0.3	0.025	0.82	**1.29**	**400**
2001	57	18	38	9	0.3	0.025	0.92	**1.44**	**447**
2002	73	19	39	8	0.3	0.025	1.05	**1.64**	**510**
2003	76	19	41	9	0.3	0.025	1.09	**1.71**	**530**
2004	48	19	40	8	0.3	0.025	0.86	**1.35**	**420**
2005	46	19	40	11	0.3	0.025	0.87	**1.36**	**422**
2006	67	17	36	4	0.3	0.025	0.93	**1.46**	**453**
2007	47	16	35	5	0.3	0.025	0.77	**1.2**	**373**
2008	51	16	35	5	0.3	0.025	0.81	**1.27**	**394**
2009	58	15	33	4	0.3	0.025	0.83	**1.31**	**405**
2010	50	16	34	4	0.3	0.025	0.78	**1.22**	**379**
2011	43	16	34	6	0.3	0.025	0.74	**1.16**	**359**
2012	50	17	37	5	0.3	0.025	0.81	**1.28**	**396**
2013	65	18	40	7	0.3	0.025	0.97	**1.52**	**472**
2014	51	20	42	6	0.3	0.025	0.89	**1.39**	**432**
2015	50	20	44	6	0.3	0.025	0.90	**1.42**	**439**
2016	51	21	44	6	0.3	0.025	0.91	**1.43**	**444**
2017	40	20	42	4	0.3	0.025	0.79	**1.24**	**386**

4.15. Prescribed Burning of Savannas (clearance of land by prescribed burning) (3.E.)

Land clearance by prescribed burning is not practiced in Georgia (NO).

4.16. Field Burning of Agricultural Residues (3.F.)

Burning of agricultural residues (crop residues is not thought to be a net source of carbon dioxide because the carbon released to the atmosphere during burning is reabsorbed during the next growing season). Calculations are carried out applying 1996 IPCC methodology.

Crop residue burning is a net source of CH_4 and N_2O. CH_4 and N_2O emissions from field burning of agriculture residues are not key sources for Georgia. In 1990-2017 share of methane emissions from this source in sectoral emissions was within 0.3–0.6% and share of Nitrous oxide emissions was within 0.1–0.3%. Carbon monoxide and nitrogen oxides are also emitted during field burning of crop residues.

$$\text{Total carbon released (tonnes of carbon)} = \sum_{\text{all crop types}} \text{annual production (tonnes of biomass per year)} \times \text{the ratio of residue to crop product (fraction)} \times \text{the average dry matter fraction of residue} \left(\frac{\text{tonnes of dry matter}}{\text{tonnes of biomass}}\right) \times \text{the fraction actually burned in the field} \times \text{the fraction oxidized} \times \text{the carbon fraction} \left(\frac{\text{tonnes of carbon}}{\text{tonnes of dry matter}}\right)$$

Trace gas emissions from burning is summarized as follows:

CH_4 Emissions = Carbon Released × (emission ratio) x 16/12

CO Emissions = Carbon Released × (emission ratio) x 28/12

N_2O Emissions = Carbon Released × (N/C ratio) x (emission ratio) x 44/28

NO_x Emissions = Carbon Released × (N/C ratio) x (emission ratio) x 46/14

There is no statistics about area burnt available in Georgia. According to the IPCC 1996 default value 0.25 was used (IPCC 1996, Reference manual, Agriculture, table 4.19)

IPCC 1996 default values are used for Dry Matter Fraction, Carbon Fraction, Nitrogen-Carbon Ratio and emission ratios (IPCC 1996, Reference manual, Agriculture, tables 4.16 and 4.17).

Emissions:
Methane and nitrous oxide emissions and carbon monoxide and nitrogen oxides emissions are presented in *Table 4-82* and *Table 4-83*.

Table 4-82 GHG Emissions from field burning of crop residues

Year	Gg CH_4	Gg N_2O	in Gg CO_2-eq	Year	Gg CH_4	Gg N_2O	in Gg CO_2-eq
1990	0.51	0.09	15	2004	0.51	0.08	15
1991	0.44	0.07	13	2005	0.53	0.09	16
1992	0.39	0.06	11	2006	0.24	0.04	7
1993	0.32	0.05	9	2007	0.31	0.05	9
1994	0.38	0.06	11	2008	0.33	0.06	10
1995	0.38	0.06	11	2009	0.27	0.04	8
1996	0.46	0.08	14	2010	0.18	0.03	5
1997	0.64	0.11	19	2011	0.30	0.05	9
1998	0.44	0.07	13	2012	0.28	0.05	8
1999	0.57	0.09	17	2013	0.35	0.06	11
2000	0.31	0.05	9	2014	0.26	0.04	8
2001	0.56	0.09	16	2015	0.27	0.05	8
2002	0.50	0.08	15	2016	0.32	0.05	9
2003	0.56	0.09	7	2017	0.23	0.04	7

Table 4-83 NOx and CO Emissions from field burning of crop residues

Year	Gg CO	Gg NOx	Year	Gg CO	Gg NOx
1990	10.7	0.5	2004	10.6	0.5
1991	9.2	0.4	2005	11.1	0.5
1992	8.1	0.4	2006	5.1	0.2
1993	6.6	0.3	2007	6.4	0.3
1994	8.0	0.4	2008	6.9	0.3
1995	7.9	0.4	2009	5.6	0.3
1996	9.6	0.5	2010	3.7	0.2
1997	13.5	0.6	2011	6.3	0.3
1998	9.2	0.5	2012	5.8	0.3
1999	11.9	0.6	2013	7.3	0.4

Year	Gg CO	Gg NOx	Year	Gg CO	Gg NOx
2000	6.6	0.3	2014	5.5	0.3
2001	11.7	0.5	2015	5.7	0.3
2002	10.5	0.5	2016	6.7	0.3
2003	11.7	0.6	2017	4.8	0.2

Chapter 5. Land use, land-use change and forestry (CRF Sector 4)

5.1. Overview of the Sector

The greenhouse gas inventory in the sector has been prepared in accordance with the new 2006 IPCC Guidelines. The old (1990-2015) and the new (2016-17) emissions / absorption estimates have also been updated.

The greenhouse inventory (GHGI) for the LULUCF sector covers the following source/sink categories: 1) Forest land (5A); 2) Cropland (5B); 3) Grassland (5C); 4) Wetlands (5D); 5) Settlements (5E) and 6) Other land (5F). In this GHGI, emissions and absorptions have been estimated for three source/sink categories: forest land, cropland, and grassland. The above mentioned categories are the key source-categories in Georgia; in addition there is sufficient data available (e.g. databases) for carrying out calculations in these categories (unlike other source/sink categories); this allows to obtain the annual parameters for greenhouse gases emissions and absorptions in order to determine the trend of annual changes.

The calculations of emissions and absorptions in the LULUCF sector have been carried out using default values of Emission Factors (Tier I approach), which correspond to the climatic conditions of Georgia according to the methodological explanations of IPCC guidelines. Carbon dioxide emissions and absorptions for each source/sink category, as well as the total sum values for 1990-2017 years period are provided in Table 6-4. Figure –6-1 presents the trend of calculated total emissions and absorptions for the entire LULUCF sector as well as specifically for the forest land category, respectively. The methodology of calculations, Activity Data and Emission Factors are described in detail further in the respective chapters. The methodological tiers used in the LULUCF sector are as shown in the Table 6-1 below.

Table 5-1 The methodological tiers used in the LULUCF sector

GHG Source and Sink Categories	CO_2		CH_4		N_2O		NOx		CO	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
5.A Forest land	D,T1	D, PS	D,T1	D	D,T1	D	D,T1	D	D,T1	D
5.B Cropland	D,T1	D,PS	NE	NE	NE	NE	NE	NE	NE	NE
5.C Grassland	D,T1	D,PS	NE	NE	NE	NE	NE	NE	NE	NE
5.D Wetlands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.E Settlements	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.F Other land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

D: IPCC default, T1-T3: IPCC Tier 1-3, PS: plant specific.

5.2. Land-use definitions, the classification systems used and their correspondence to the land use, land-use change and forestry categories

Greenhouse gas inventories in the source categories were carried out taking into account the land use classifications specified in the IPCC Guidelines - *Table 5-2**2***.

Table 5-2 Land-use definitions and the classification

Land-use definitions	Land-use classification
Forest Land	This category includes all land with woody vegetation consistent with thresholds used to define Forest Land in the national greenhouse gas inventory. It also includes systems with a vegetation structure that currently fall below but could potentially reach the threshold values used by the country to define the Forest Land category.
Cropland	This category includes cropped land, including rice fields, and agroforestry systems where the vegetation structure falls below the threshold used for the Forest Land category.
Grassland	This category includes rangelands and pastureland that are not considered cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pasture systems, consistent with national definitions.
Wetlands	This category includes areas of peat extraction and land that is covered or saturated by water the whole or part of the year (e.g., peatlands) and does not fall under the Forest Land, Cropland, Grassland or Settlements categories. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.
Settlements	This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included in any of other categories. This should be consistent with national definitions.
Other Land	This category includes bare soil, rock, ice, and all land areas that do not fall under any of the other five categories. It allows the total of identified land areas to match the national area, where data is available. If data is available, countries are encouraged to classify unmanaged lands by the above land-use categories (e.g., into Unmanaged Forest Land, Unmanaged Grassland, and Unmanaged Wetlands). This will improve transparency and enhance the ability to track land-use conversions from specific types of unmanaged lands into the categories above.

5.3. Approaches for estimating land areas and land-use database used for the inventory preparation

Indicators of changes in land and land use are mainly based on data from the National Statistics Office and FAOSATA. Data from the Ministry of Environment and Agriculture of Georgia and the Ajara Forestry Agency are used as well.

5.3.1. Survey methods of major land area statistics

Presently, statistics on land categories are difficult to obtain, given that the most recent property survey was conducted in Georgia in 2003. Forest registration has also been suspended for years. All this makes it difficult to obtain reliable data.

5.3.2. Land area estimation methods

As we have already mentioned, the greenhouse gas inventory report contains six source/sink categories (land use categories), for which GHG emissions and absorptions are determined separately, per each change in land use categories, that are calculated by the following formula:

$$\Delta C_{AFOLU} = \Delta C_{FL} + \Delta C_{CL} + \Delta C_{GL} + \Delta C_{WL} + \Delta C_{SL} + \Delta C_{OL}$$

Where:

ΔC_{AFOLU} = carbon stock change
Indices denote the following land-use categories:
FL = Forest land
CL = Cropland

GL = Grassland
WL = Wetlands
SL = Settlements
OL = Other land

The methodology of greenhouse gas inventory is based on the so-called Good Practice Guidance principles that implies carrying out calculations according to tiers. In particular, there are the following tiers: Tier 1 approach is feasible even when country-specific Activity Data and emission/absorption factors are not available, and works when changes of the carbon pool in biomass on *Forest Land Remaining Forest Land* are relatively small. The method requires the biomass carbon loss to be subtracted from the biomass carbon gain. The annual change in carbon stocks in biomass can be estimated using the gain-loss method; Tier 2 approach can be used in countries where country-specific Activity Data and emission/absorption factors are available or can be gathered at reasonable cost. The Tier 3 approach for biomass carbon stock change estimation allows for a variety of methods, including process- based models. Implementation may differ from one country to another, due to differences in inventory methods, forest conditions and Activity Data.

The selection of the tier methodology acceptable for calculations depends on availability of the necessary data. While selecting the appropriate tier for improving the process of inventory development, attention must be paid to those source/sink categories (land use categories) of emissions/absorptions, where changes in carbon stock are significant in comparison with others, so that they may be considered as a key source category.

5.3.3. Land-use transition matrix

According to IPCC requirements, the existence of annual Activity Data on land use and land-use changes is important and essential for the inventory in this sector.

Proceeding from these requirements, *Table 5-3* was compiled based mainly on data from the National Statistics Office and the Ministry of Environmental Protection and Agriculture, indicating the respective areas of land use categories determined by IPCC guidelines and changes occurred in them in years 1990-2017. To obtain certain data, taking into account the unavailability of information from the above-mentioned institutions, the FAOSTAT database has also been used.

During the inventory development process, changes in the land use category were noted in various directions. There is a trend of decline in forest lands and croplands. Cropland has been significantly reduced; namely in 2017 the total area (including areas covered by perennials) decreased by 21% compared to 1990.

Generally, it can be said that changes in land use areas are minimal. It is noteworthy that the small change in the total forest area of Georgia is due to the fact that no clear cut is carried out there and the tendency to transfer forest lands to other land use categories is insignificant.

Table 5-3 Distribution of the Territory of Georgia According to Various Land Use Categories (following IPCC classification), (including Abkhazia and South Ossetia), thousand ha

Year	**Land use subcategories**						**Total area of Georgia** (Including territorial waters)
	5A.	**5B.**	**5C.**	**5D.**	**5E.**	**5F.**	
	Forest land	**Cropland**	**Grassland**	**Wetlands**	**Settlements**	**Other land**	
1990	2752.3	1147.9	1956.5	835.1	211.2	725.4	7628.4
1991	2752.3	1143.4	1961.5	835.1	211.2	724.9	7628.4
1992	2752.3	1125.3	1966.6	835.1	211.2	737.9	7628.4

Year	Land use subcategories						Total area of Georgia (Including territorial waters)
	5A.	5B.	5C.	5D.	5E.	5F.	
	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	
1993	2752.3	1124.3	1971.6	835.1	211.2	733.9	7628.4
1994	2752.3	1123.3	1976.5	835.1	211.2	730.0	7628.4
1995	2752.3	1099.6	1978.1	835.1	211.2	752.1	7628.4
1996	2752.3	1078.9	1979.7	835.1	211.2	771.2	7628.4
1997	2752.3	1073.2	1981.3	835.1	211.2	775.3	7628.4
1998	2773.4	1049.1	1982.9	835.1	211.2	776.7	7628.4
1999	2773.4	1025.0	1984.5	835.1	211.2	799.2	7628.4
2000	2773.4	1001.0	1986.5	835.1	211.2	821.2	7628.4
2001	2773.4	977.4	1988.1	835.1	211.2	843.2	7628.4
2002	2773.4	953.8	1989.7	835.1	211.2	865.2	7628.4
2003	2773.4	930.2	1991.3	835.1	211.2	887.2	7628.4
2004	2773.4	906.4	1992.9	835.1	211.2	909.4	7628.4
2005	2772.4	918.1	1994.5	835.1	211.2	897.1	7628.4
2006	2772.4	924.1	1996.5	835.1	211.2	889.1	7628.4
2007	2772.4	922.1	1996.5	835.1	211.2	891.1	7628.4
2008	2772.4	923.1	1996.5	835.1	211.2	890.1	7628.4
2009	2772.4	933.1	1996.5	835.1	211.2	880.1	7628.4
2010	2733.8	933.1	1996.5	835.1	211.2	918.7	7628.4
2011	2733.8	933.1	1996.5	835.1	211.2	918.7	7628.4
2012	2732.8	933.1	1996.5	835.1	211.2	919.7	7628.4
2013	2732.8	938.1	1996.5	835.1	211.2	914.7	7628.4
2014	2733.9	918.1	1996.5	835.1	211.2	933.6	7628.4
2015	2746.5	918.1	1996.5	835.1	211.2	921.0	7628.4
2016	2746.5	918.1	1996.5	835.1	211.2	921.0	7628.4
2017	2747.1	928.9	1996.5	835.1	211.2	909.6	7628.4

5.4. Parameters for estimating carbon stock changes from land use conversions

Table 5-4 Carbon Stock Changes and Net CO_2 Emissions and Absorptions in the LULUCF Sector

Year	Forest lands		Croplands				Grasslands		Net emission/absorption	
			Perennial crops		Arable lands					
	Thousand tC	Gg CO_2	Thousand tC	Gg CO_2	Thousand tC	Gg CO_2	Thousand tC	Gg CO_2	Thousand tC	Gg CO_2
1990	1697.5	-6224.2	748.9	-2746.0	77.4	-283.9	-791.2	2901.0	1732.7	-6353.1
1991	1697.7	-6224.8	730.0	-2676.5	114.5	-419.9	-792.5	2905.8	1749.6	-6415.4
1992	1704.1	-6248.4	663.4	-2432.4	148.0	-542.6	-793.9	2911.0	1721.6	-6312.5
1993	1701.0	-6237.0	697.2	-2556.4	181.5	-665.4	-793.8	2910.5	1785.9	-6548.2
1994	1692.0	-6204.0	695.1	-2548.7	214.9	-788.1	-795.1	2915.3	1806.9	-6625.5
1995	1711.6	-6276.0	592.2	-2171.4	201.5	-739.0	-794.5	2913.3	1710.8	-6273.0
1996	1696.2	-6219.5	552.3	-2025.1	188.1	-689.8	-794.3	2912.4	1642.4	-6022.0
1997	1677.0	-6149.1	569.1	-2086.7	174.7	-640.7	-794.0	2911.4	1626.8	-5965.1
1998	1660.9	-6089.9	477.2	-1749.6	161.3	-591.6	-793.8	2910.5	1505.6	-5520.5
1999	1673.7	-6136.9	423.8	-1553.8	147.9	-542.4	-793.5	2909.5	1451.9	-5323.5
2000	1661.2	-6091.0	370.5	-1358.4	134.6	-493.7	-794.1	2911.7	1372.2	-5031.3
2001	1666.1	-6109.1	317.1	-1162.6	143.3	-525.5	-793.3	2908.6	1333.3	-4888.6
2002	1681.0	-6163.7	263.8	-967.1	152.0	-557.4	-793.6	2910.0	1303.2	-4778.2
2003	1624.4	-5956.2	210.5	-771.7	160.7	-589.2	-793.8	2910.6	1201.8	-4406.6
2004	1598.9	-5862.5	156.2	-572.9	169.4	-621.1	-794.0	2911.2	1130.5	-4145.3
2005	1499.2	-5497.2	252.0	-924.0	178.1	-653.1	-794.1	2911.8	1135.2	-4162.5
2006	1490.3	-5464.5	256.2	-939.4	208.6	-764.8	-794.2	2912.1	1160.9	-4256.6

Year	Forest lands		Croplands				Grasslands		Net emission/absorption	
			Perennial crops		Arable lands					
	Thousand tC	Gg CO_2	Thousand tC	Gg CO_2	Thousand tC	Gg CO_2	Thousand tC	Gg CO_2	Thousand tC	Gg CO_2
2007	1488.5	-5457.8	235.2	-939.4	239.0	-876.5	-794.2	2912.1	1189.5	-4284.7
2008	1469.4	-5387.9	243.6	-893.2	269.5	-988.2	-794.2	2912.1	1188.3	-4357.2
2009	1546.0	-5668.6	237.3	-870.1	300.0	-1099.9	-794.2	2912.1	1289.1	-4593.9
2010	1466.1	-5375.6	235.2	-862.4	330.4	-1211.4	-794.2	2912.1	1237.4	-4537.3
2011	1564.6	-5736.7	228.9	-839.3	327.3	-1200.1	-794.2	2912.1	1326.6	-4864.0
2012	1531.9	-5616.9	228.9	-839.3	328.8	-1205.6	-794.2	2912.1	1295.4	-4749.7
2013	1580.3	-5794.3	231.0	-847.0	301.3	-1104.8	-794.2	2912.1	1318.4	-4834.0
2014	1499.5	-5498.3	231.0	-847.0	320.6	-1175.4	-794.2	2912.1	1256.9	-4608.6
2015	1495.7	-5484.3	231.0	-847.0	326.6	-1197.5	-794.2	2912.1	1259.1	-4616.8
2016	1532.0	-5617.4	231.0	-847.0	339.4	-1244.4	-794.2	2912.1	1308.2	-4796.6
2017	1521.3	-5578.1	276.4	-1013.4	339.4	-1244.4	-794.2	2912.1	1342.8	-4923.8

Figure 5-1 Dynamics of net CO_2 emissions/absorption in the "Land Use, Land-Use Change and Forestry" sector

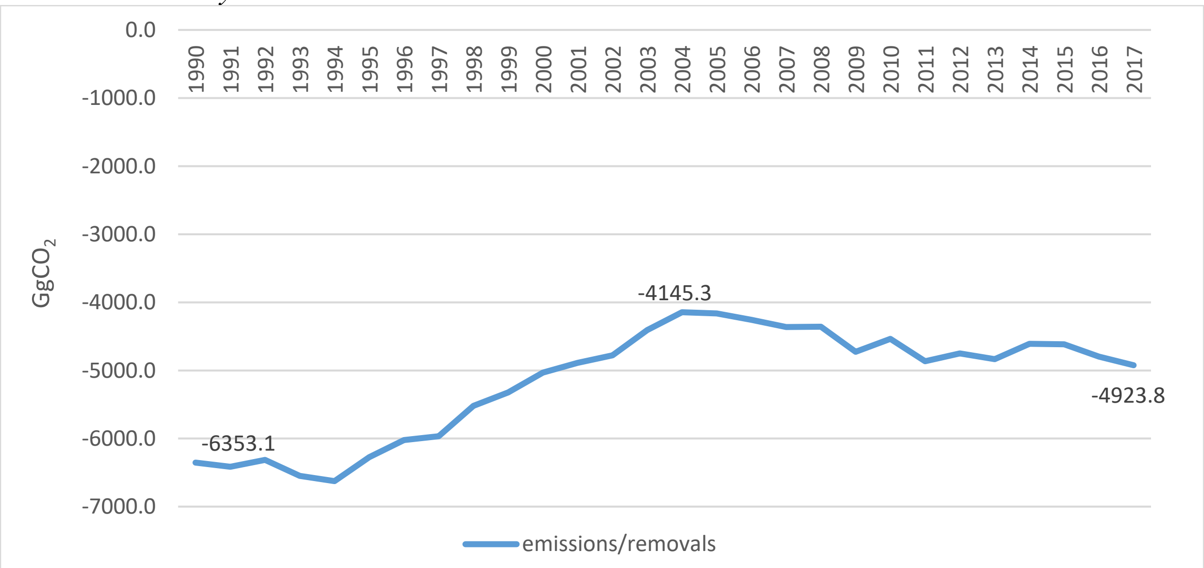


Figure 5-2 Dynamics of net CO_2 emissions/absorptions in the forest land (on territories covered with forest)

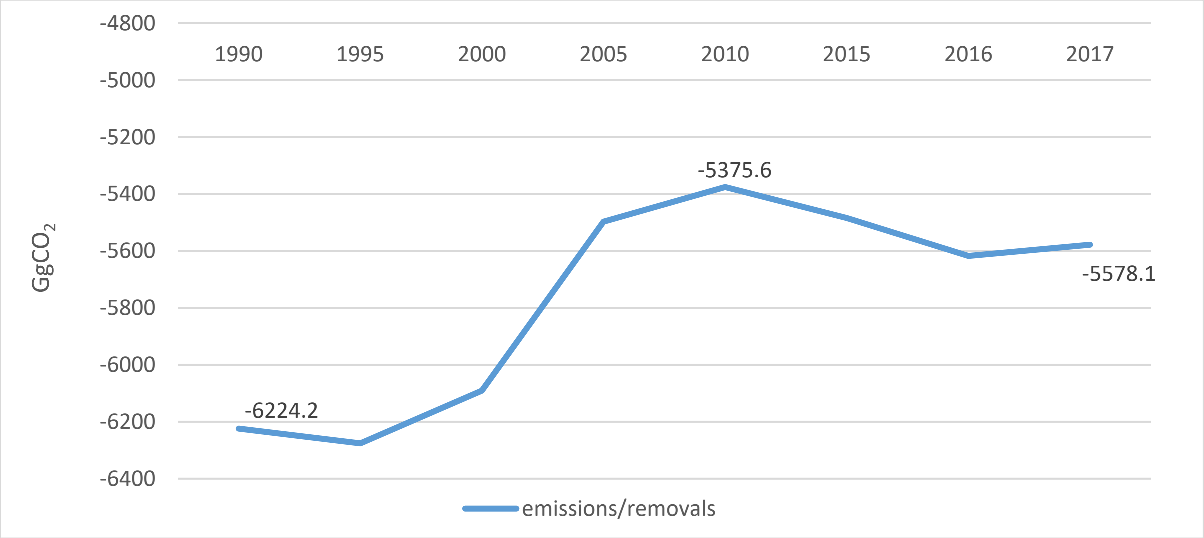


Figure 5-3 Dynamics of net CO_2 emissions/absorptions in the croplands

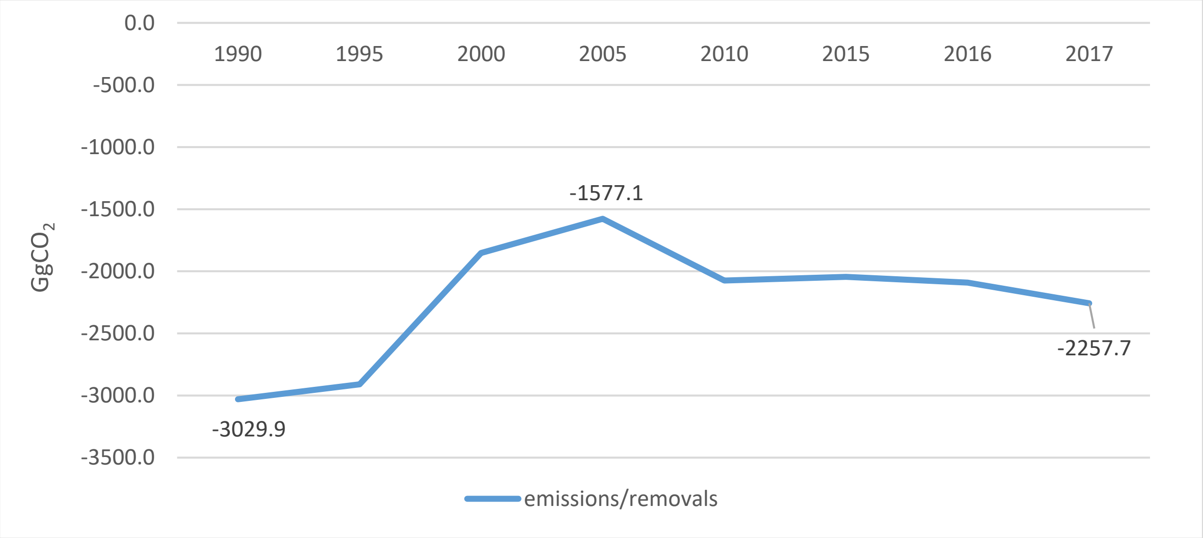
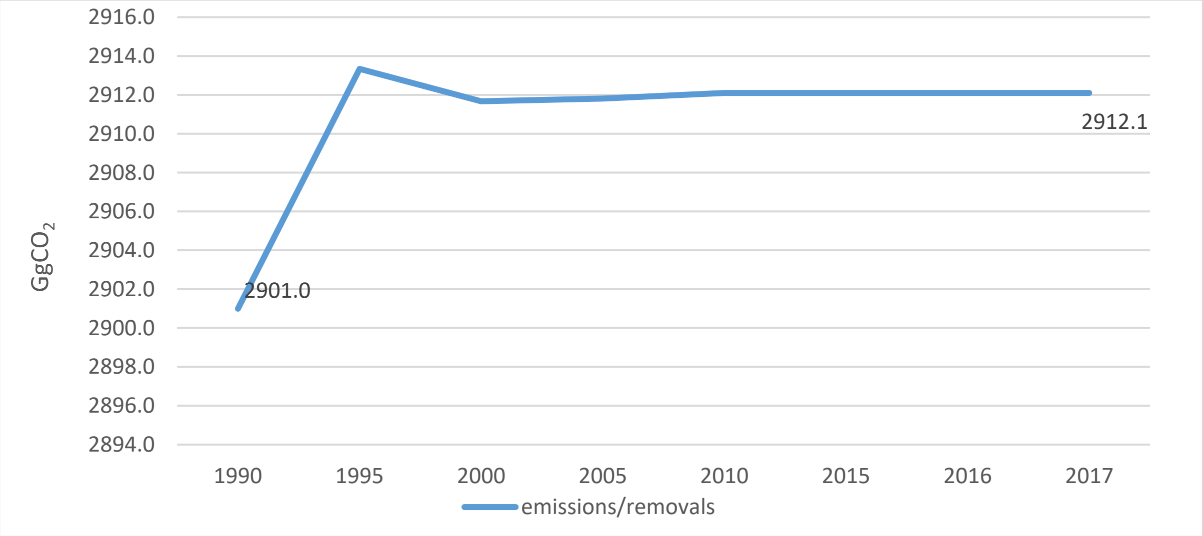


Figure 5-4 Dynamics of net CO_2 emissions/absorptions in the Grasslands



As seen in the given graphs, the sector accumulates carbon dioxide, although a trend of decline is obvious. Namely in 1990 the accumulated volume was about 6353.1 $GgCO_2$, while in 2017 net emissions decreased by 23 %, amounting to 4923.8Gg CO_2.

5.5. Forest land (4.A.)

a) Source-category description and calculated emissions

Within the framework of this report, greenhouse gas inventories for Georgian forests were carried out on an entire forest area, regardless of forest management regime (active or passive). Specifically, the calculations include part of the forest area within protected areas where any forest use measures (eg Nature strict reserve IUCN category 1) are prohibited by Georgian legislation, since these areas are considered to be managed forests despite passive management. Exceptions are forests in areas not controlled by Georgia (Abkhazia, so called South Ossetia), which are not included in the calculation due to the lack of relevant data.

The aim of calculations is to elucidate what a forest is – an absorber or, on the contrary, an emitter of carbon dioxide, which determines balance of volume of reduction of biomass, the biomass growth and volume of reforestation, forest yield.

Using the necessary Activity Data for the inventory and Emission Factors, the work sheets have been filled in and emissions and absorptions have been calculated. According to the obtained results the values of carbon dioxide emissions and absorptions are provided in *Table 5-5*.

With regard to CO_2 emissions as a result of forest fires, emissions of other greenhouse gases obtained by calculations are provided in *Table 5-6*.

Table 5-5 Carbon Stock Changes and CO_2 net Emissions from Living Biomass in Forest Lands in Georgia

Year	forest land, thousand ha	Carbon gains, thousand tons C	Carbon losses thousand tons C	Net carbon stock change, thousand tons C	Carbon dioxide net emissions/absorptions, Gg CO_2
1990	2127.5	1831.9	134.4	1697.5	6224.2
1991	2127.5	1831.9	134.2	1697.7	6224.8
1992	2127.5	1831.9	127.8	1704.1	6248.4
1993	2127.5	1831.9	130.9	1701.0	6237.0
1994	2127.5	1831.7	139.7	1692.0	6204.0
1995	2127.5	1831.7	120.1	1711.6	6276.0
1996	2127.5	1831.7	135.5	1696.2	6219.5
1997	2127.5	1831.7	154.7	1677.0	6149.1
1998	2150.3	1836.5	175.6	1660.9	6089.9
1999	2150.3	1836.5	162.8	1673.7	6136.9
2000	2150.3	1835.8	174.6	1661.2	6091.0
2001	2150.3	1835.8	169.6	1666.1	6109.1
2002	2150.3	1835.8	154.8	1681.0	6163.7
2003	2150.3	1835.8	211.3	1624.4	5956.2
2004	2150.3	1835.8	236.9	1598.9	5862.5
2005	2149.3	1809.8	310.5	1499.2	5497.2
2006	2149.3	1809.8	319.5	1490.3	5464.5
2007	2149.3	1809.8	321.3	1488.5	5457.8
2008	2149.3	1809.8	340.3	1469.4	5387.9
2009	2149.3	1809.8	263.8	1546.0	5668.6
2010	2110.7	1765.1	299.0	1466.1	5375.6
2011	2110.7	1809.3	244.8	1564.6	5736.7
2012	2109.7	1759.3	227.4	1531.9	5616.9
2013	2109.7	1831.9	251.6	1580.3	5794.3
2014	2110.8	1759.7	260.1	1499.5	5498.3
2015	2123.4	1766.6	270.9	1495.7	5484.3
2016	2123.4	1766.6	234.6	1532.0	5617.4
2017	2124.0	1766.9	245.6	1521.3	5578.1

Table 5-6 Greenhouse Gas Emissions as a Result of Forest Fires in Forest land of Georgia

Year	Greenhouse gas emission 10^{-3} Gg			
	CH_4	CO	N_2O	NO_X
1990	2.01	29.07	0.02	0.16
1991	0.61	8.78	0.01	0.05
1992	NE	NE	NE	NE
1993	5.51	79.56	0.07	0.43
1994	48.37	698.61	0.59	3.76
1995	1.42	20.48	0.02	0.11
1996	32.40	468.00	0.40	2.52
1997	15.31	221.13	0.19	1.19

Year	Greenhouse gas emission 10^{-3} Gg			
	CH_4	CO	N_2O	NO_X
1998	31.21	450.74	0.38	2.43
1999	6.76	97.67	0.08	0.53
2000	18.93	273.49	0.23	1.47
2001	2.01	29.07	0.15	0.16
2002	36.88	532.64	0.45	2.87
2003	4.21	60.84	0.05	0.33
2004	5.18	74.88	0.06	0.40
2005	1.81	26.21	0.02	0.14
2006	124.37	1796.42	1.52	9.67
2007	0.24	3.42	0.00	0.02
2008	362.17	5231.36	4.43	28.17
2009	2.01	29.07	0.53	0.16
2010	30.06	434.19	0.37	2.34
2011	0.28	4.10	0.00	0.02
2012	12.07	174.40	0.15	0.94
2013	2.01	29.07	0.09	0.16
2014	58.51	845.09	0.72	4.55
2015	2.01	29.07	0.20	0.16
2016	11.15	161.02	0.14	0.87
2017	78.97	1140.66	0.97	6.14

b) *Methodological issues*

- ***Estimation Method***

In accordance with the IPCC methodology, carbon in the forest sector is accumulated in or released from the so called “pools”: 1) living biomass (above-ground and below-ground); 2) dead organic matter (dead wood, litter); 3) soils (mineral and organic). Explanation of these pools is provided in *Table 5-7*.

Based on materials needed for inventory obtained in advance, and the IPCC guidelines the key category for calculations has been selected, namely, “Forest land; remaining forest land”. As we have already noted, this was stipulated by the fact that in Georgia the number of cases of forest area conversions into areas of other categories or vice versa is negligible. A “living biomass” has been selected from the carbon pools, since based on conditions in the forestry sector of Georgia and natural-ecological state this is where the main changes in carbon stocks take place.

As it has already been mentioned, calculations were made according to the Tier 1 approach, and calculations were made for living biomass. Calculations were not carried out in relation of dead organic material and soil carbon reservoirs. This is in line with the forest management system in Georgia, in other words in most cases clear logging does not take place in forests of Georgia and accordingly no significant changes occur in the mentioned two pools.

Table 5-7 Explanation of Carbon Pools

№	Carbon “reservoirs”		Explanation
1	Living Biomass	Above ground biomass	All living above ground biomass (timber, stumps, branches, bark, leaves, etc.).
		Below ground biomass	All living biomass of live root system
2	Dead Organic Matter	Dead wood	All dead wood fallen down on the soil not decayed
		Litter	All dead cover (humus) on about 10 centimeters depth
3	Soils	Organic matter of soil	Organic carbon in determined depth of mineral and organic soils (including peats).

The schematic diagram of formulas needed for calculation of carbon accumulation and release in the remaining forest land is provided in *Figure 5-5* The System of Equations For Calculation Of The Amount Of Carbon Accumulation In Biomass. At this stage, the calculation has only been carried out for the "above-ground and below ground biomass", based on the available materials i.e. in the pool of living biomass. As it was mentioned, calculations were made for so called living biomass (Tier 1 approach).

Figure 5-5 The System of Equations For Calculation Of The Amount Of Carbon Accumulation In Biomass

$$\Delta C_{FF} = (\Delta C_{FF_{LB}} + \Delta C_{FF_{DOM}} + \Delta C_{FF_{SOILS}})$$

$$\Delta C_{FF_{LB}} = (\Delta C_{FF_G} - \Delta C_{FF_L})$$

$$C_{FF_G} = (A \cdot G_{TOTAL}) \cdot CF$$

$$\Delta C_{FF_L} = L_{fellings} + L_{fuelwood} + L_{other\ losses}$$

$$G_{TOTAL} = G_W \cdot (1+R)$$

$$G_W = I_V \cdot D \cdot BEF_1$$

$$L_{fellings} = H \cdot D \cdot BEF_2 \cdot (1 - F_{BL}) \cdot CF$$

$$L_{fuelwood} = FG \cdot D \cdot BEF_2 \cdot CF$$

$$L_{other\ losses} = A_{DISTURBANCE} \cdot B_W \cdot (1 - F_{BL}) \cdot CF$$

Where:

ΔCFF annual change in carbon stocks from forest land remaining forest land, tonnes C yr-1;

ΔC_{FFLB} annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land remaining forest land; tonnes C yr-1;

ΔC_{FFDOM} annual change in carbon stocks in dead organic matter (includes dead wood and litter) in forest land remaining forest land; tonnes C yr-1;

$\Delta C_{FFSOILS}$ annual change in carbon stocks in soils in forest land remaining forest land; tonnes C yr-1;

ΔC_{FFG}annual increase in carbon stocks due to biomass growth, tonnes C yr-1;

ΔC_{FFL}- annual decrease in carbon stocks due to biomass loss, tonnes C yr-1;

A - Area of remaining forest land, by forest type, ha;

G_{TOTAL}- average annual increment rate in total biomass in units of dry matter, by forest type and climatic zone, tonnes d.m. ha-yr;

CF-carbon fraction of dry matter (default = 0.5), tons C (tonnes d.m.)-1;

G_W-average annual aboveground biomass increment, tonnes d.m. ha-1 yr-1;

I_V- =average annual net increment in volume suitable for industrial processing, m3 ha-1 yr-1;

D-basic wood density, tonnes d.m. m-3;

BEF_1- biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment, dimensionless.

R – root-to-shoot ratio appropriate to increments, dimensionless.

$L_{fellings}$ – annual carbon loss due to commercial felling, tonnes C yr-1

$L_{fuelwood}$- annual carbon loss due to fuelwood gathering, tonnes C yr-1

$L_{other\ losses}$ –annual other losses of carbon, tonnes C yr-1

H-annually extracted volume, roundwood, m3 yr-1;

BEF_2-biomass expansion factor for converting volumes of extracted roundwood to total aboveground biomass (including bark), dimensionless.

F_{BL}- fraction of biomass left to decay in forest (transferred to dead organic matter);

FG- annual volume of fuelwood gathering, m3 yr-1;

B_W-average biomass stock of forest areas, tonnes d.m. ha-1;

In addition to the natural processes that take place on forest lands and changes in carbon stock due to timber production, emissions of CO_2 and other greenhouse gases into the atmosphere resulting from forest fires have also been calculated.

CH_4, N_2O, CO, and NO_X gases are also emitted along with carbon because of forest fires.

The available methodology allows to determine quantities of greenhouse gases (CH_4, N_2O), other than carbon dioxide released due to forest fires.

As for estimation of other greenhouse gases (CH_4, N_2O) the following equation[98] is used:

$$L_{FIRE}=A\times B\times C\times D\times 10^{-6}$$

Where:

A area burnt, ha;
B-mass of 'available' fuel, kg d.m. ha-1;
C-combustion efficiency (or fraction of the biomass combusted), dimensionless.
D-emission factor, g (kg d.m.)-1;

The mentioned formulas allow calculating quantities of all greenhouse gases separately, since emission factors for various gases differ (see the *Table 5-14*).

- ***Emission factors***

Absolute dry volume weight of timber (D) has been calculated for forest massifs with different climate in Western and Eastern Georgia and also for coniferous and deciduous species separately.

Data on dominating forest species in all three regions have been used for the calculations. The obtained values for volume weight of timber are provided in *Table 5-8, Table 5-9* and *Table 5-10*.

[98]Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 3, GREENHOUSE GAS EMISSIONS FROM BIOMASS BURNING, IPCC 2003,http://www.ipcc-nggip.iges.or.jp

Table 5-8 Basic Wood Density and Volumes of Reserves of Deciduous and Coniferous Forests in West Georgia (Humid Continental Climate) Volumes of Reserves Are Obtained by Averaging Data for 2006[99]

Dominant forest species	Reserves of dominating species (m^3) and share in total reserves (%)	Basic wood density timber, t dm/m^3[100]
Deciduous		
Beech	71 170 (52%)	0.58
Chestnut	30 792 (22%)	0.48
Alder	19 426 (14%)	0.45
Oak	9 009 (6%)	0.66
Hornbeam	6 015 (4%)	0.74
Total	136 412 (100%)	
	Basic wood density	**0.55**
Coniferous		
Fir	49 236 (76%)	0.41
Spruce	14 258 (22%)	0.44
Pine	1 253 (2%)	0.48
Total	64 747 (100%)	
	Basic wood density	**0.42**

Table 5-9 Basic Wood Density and Volumes of Reserves of Deciduous and Coniferous Forests in East Georgia (Dry Continental Climate) Volumes of Reserves Are Obtained based on Average Data of 2006[101]

Dominant forest species	Reserves of dominating species (m^3) and share in total reserves (%)	Basic wood density timber, t dm/m^3[33]
Deciduous		
Beech	65 569 (37%)	0.58
Oak	61 085 (34%)	0.66
Hornbeam	39 250 (22%)	0.74
Oriental hornbeam	9 369 (5%)	0.74
Maple	4 025 (2%)	0.65
Total	179 298 (100%)	
	Basic wood density	**0.65**
Coniferous		
Spruce	21 365 (61%)	0.48
Pine	10 025 (30%)	0.41
Fir	3 258 (9%)	0.44
Total	34 648 (100%)	
Basic wood density		**0.45**

[99] Georgian Statistical Yearbook of Forestry, Ministry of Environment and Natural Resources of Georgia, Forestry Department, Tbilisi, 2006;

[100]Makhviladze S.E. Wood science, Tbilisi 1962 (in Georgian); Боровиков А.М., Уголев Б.Н. Справочник по древесине. “Лесная Промышленность”, Москва, 1989;

[101] Georgian Statistical Yearbook of Forestry, Ministry of Environment and Natural Resources of Georgia, Forestry Department, Tbilisi, 2006;

Table 5-10 Basic Wood Density and Volumes of Reserves of Deciduous and Coniferous Forests in Ajara AR

Dominant forest species	Reserves of dominating species (m^3) and share in total reserves (%)	Basic wood density timber, t/m^3[33]
Deciduous		
Beech	24170 (73%)	0.58
Chestnut	5792 (18%)	0.48
Alder	1426(4%)	0.45
Hornbeam	1009(3%)	0.74
Oak	715(2%)	0.66
Total	33112(100%)	
	Basic wood density	**0.56**
Coniferous		
Fir	8386(50%)	0.415
Spruce	8051(48%)	0.44
Pine	298(2%)	0.48
Total	16735(100%)	
Basic wood density		**0.43**

The percentage distribution of stocks of dominating species has been taken into consideration in calculations of average volume weights provided in the Tables. It should be noted that in accordance with IPCC Guidelines the values of volume weight of dominating species in the countries of moderate climate in fact coincide with the country specific values of dominating species of Georgia. IPCC value for deciduous species (species -beech) equals 0.58 t dm/m^3, and for coniferous ones (species -fir tree) - 0.40 t dm/m^3.

With regard to the value of volume weight used in calculations of biomass losses, it was obtained taking into account the main species of timber produced in Georgia. Since volume of timber produced by cutting are not identified by species on a national scale in Georgia, therefore expert estimation has been used to determine percentage values of the main species, used by population as timber and firewood. In particular, the following species are produced in Georgia as timber: beech - 70%, fir-tree - 15%, spruce - 10% and other - 5%, and as firewood: beech - 35%, hornbeam - 30%, oriental hornbeam - 20% and other - 15%. Taking into consideration the above-mentioned percentage values, the average value of volume weight of absolutely dry timber has been calculated (*Table 5-11*).

Table 5-11 Absolutely Dry Volume of Commercial Timber and Fire Wood Produced in Georgia

Dominant forest species	Share in total reserves (%)	Basic wood density timber, t dm/m^3[102]
Roundwood		
Beech	70	0.58
Spruce	15	0.48
Fir	10	0.41
Other	5	NO
	100	
Basic wood density		**0.52**
Firewood		
Beech	35	0.58
Hornbeam	30	0.74
Oriental hornbeam	20	0.74

[102]Makhviladze. Timbers, Tbilisi 1962; Боровиков А.М., Уголев Б.Н. Справочникподревесине. “ЛеснаяПромышленность”, Москва, 1989.

Dominant forest species	Share in total reserves (%)	Basic wood density timber, t dm/m3[102]
Other	15	NO
	100	
Basic wood density		**0.57**

The majority of parameters indicated in the equations provided on the *Figure 5-5* The System of Equations For Calculation Of The Amount Of Carbon Accumulation In Biomass have been taken from IPCC methodology from Tables designed for countries with moderate climate. *Table 5-12* demonstrates a list of certain parameters, used in the calculations indicating the respective source.

Table 5-12 Parameters Used in Inventory and Their Values

Factors	West Georgia		East Georgia		AR of Ajara		Source
	Deciduous	Coniferous	Deciduous	Coniferous	Deciduous	Coniferous	
CF- carbon fraction of dry matter, tonnes C (tonnes d.m.)	0.48	0.51	0.48	0.51	0.48	0.51	Agriculture, Forestry and Other Land Use (AFOLU), Forest land, Table 4.3
BEF_1- biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment, dimensionless;	1.20	1.15	1.20	1.05	1.20	1.15	(IPCC 2003), Table 3A.1.10
R – root-to-shoot ratio appropriate to increments, dimensionless	0.23	0.29	0.23	0.29	0.23	0.29	Agriculture, Forestry and Other Land Use (AFOLU), Forest land, Table 4.4
BEF_2 -biomass expansion factor for converting volumes of extracted roundwood to total aboveground biomass (including bark)	1.35						(IPCC 2003), Table 3A.1.10

According to the data obtained from the National Forestry Agency and Forestry Agency of Adjara, forest fires of various intensity were registered on forest areas during the period of inventory. As a result, various volumes of biomass, enveloped in flames have been burnt on these areas. The burnt areas are provided in *Table 5-13*.

Table 5-13 Burnt Areas Registered in Georgia in 1990-2017[103]

Year	Number of fire cases	Burnt areas, ha	Average above-ground biomass of areas affected, tonnes dm ha^{-1}	Year	Number of fire cases	Burnt areas, ha	Average above-ground biomass of areas affected, tonnes dm ha^{-1}
1990	1	14.2	35	2004	21	32.0	40
1991	1	10.0	15	2005	16	44.9	10
1992	NE	NE	NE	2006	87	767.7	40
1993	7	34.0	40	2007	1	3.9	15
1994	10	341.2	35	2008	32	1277.5	70
1995	1	7.0	50	2009	15	717.4	15
1996	7	200.0	40	2010	6	371.1	20
1997	11	108.0	35	2011	4	7.0	10

[103] Georgian Statistical Yearbook, Ministry of Environment Protetion and Agriculture of Georgia, National Forestry Agency.

Year	Number of fire cases	Burnt areas, ha	Average above-ground biomass of areas affected, tonnes dm ha^{-1}	Year	Number of fire cases	Burnt areas, ha	Average above-ground biomass of areas affected, tonnes dm ha^{-1}
1998	31	308.2	25	2012	12	198.7	15
1999	13	37.1	45	2013	35	87.6	20
2000	34	85.0	55	2014	66	722.3	20
2001	28	148.0	20	2015	72	205.4	20
2002	36	607.0	15	2016	42	183.5	15
2003	5	52.0	20	2017	55	1299.9	15

Volumes of greenhouse gases emitted due to fires were calculated, as we have already mentioned, based on the IPCC equation 3.2.20[104].

Since substantiated values of factors, needed for calculations, are not available in Georgia, calculations for this source-category have been carried out by the Tier 1 approach. The coefficients have been taken from methodological Tables: IPCC Table 3A.1.12; Table 3A.1.16 Values implied for countries with moderate climate from these Tables have been used, in particular:

C- combustion efficiency =0.45 (IPCC Table 3A.1.12)

As for the emission factors, their values are provided in *Table 5-14*.

Table 5-14 Values of Emission Factors for Individual Greenhouse Gases (IPCC Table 3A.1.16)

Gas	(Emission factor, g/kg d.m.)
CH_4	9.00
CO	130.00
N_2O	0.11
NO_X	0.70

- ***Activity Data***

The areas covered by state forests in Georgia in 1990-2017 years period are provided in *Table 5-15*. Forest areas in the western and eastern parts of the country are identified separately, since the natural and climatic conditions of Western and Eastern Georgia differ from each other, therefore forest covers differ as well. Western Georgia is characterized by a humid subtropical climate; once we move from the Black sea to eastern direction, reduction of precipitation occurs simultaneously with the climate transformation into moderately dry continental climate. It should be noted that in these two parts of the country there are regions with distinguished climate or forest characteristics (e.g. Upper Svaneti).

Unfortunately, it is impossible to carry out inventory of greenhouse gases on forest areas per separate climatic zones, due to unavailability of necessary statistical or taxation data. Therefore, the calculations have been carried out according to units of regional management, namely forest plots under the National Forestry Agency, based on inventory data for these plots. From the available data on those forest plots it became clear, which climate parameters and forest cover (dominating species, growth parameters) relatively differ from adjacent regions; calculations for these plots have been carried out separately. For example, separate calculations have been carried out for Upper Svaneti (Mestia) and Borjomi-Bakuriani

[104] Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 3, EQUATION 3.2.20. https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/GPG_LULUCF_FULL.pdf

forests. Forest areas in the protected areas of Georgia and the forests under the management of Ajara AR have also been treated separately for the GHGI.

The data on average forest yield for forest types located in various climatic zones have been treated separately, based on unified forest inventory data, 2003 (*Table 5-17*).

Table 5-15 Forest areas of Georgia, According to Different Climatic Zones in Regions, ha

Year	Forest land (National Forestry Agency), ha										
	West Georgia					East Georgia					Total
	humid continental climate (Upper Svaneti -Mestia)		humid subtropical climate[105]		Total	dry continental climate[106]		humid continental climate (Borjomi-Bakuriani)		Total	(6+11)
	coniferous	deciduous	Coniferous	deciduous		coniferous	deciduous	coniferous	deciduous		
1	2	3	4	5	6	7	8	9	10	11	12
1990	46050	36183	82621	692953	857807	129166	749345	28813	21966	929290	1787097
1991	46050	36183	82621	692953	857807	129166	749345	28813	21966	929290	1787097
1992	46050	36183	82621	692953	857807	129166	749345	28813	21966	929290	1787097
1993	46050	36183	82621	692953	857807	129166	749345	28813	21966	929290	1787097
1994	46050	36183	82621	692953	857807	129223	750288	28756	21023	929290	1787097
1995	46050	36183	82621	692953	857807	129223	750288	28756	21023	929290	1787097
1996	46050	36183	82621	692953	857807	129223	750288	28756	21023	929290	1787097
1997	46050	36183	82621	692953	857807	129223	750288	28756	21023	929290	1787097
1998	46050	36183	80004	678123	840360	126010	734601	28756	21023	910390	1750750
1999	46050	36183	80004	678123	840360	126010	734601	28756	21023	910390	1750750
2000	46050	36183	80004	678123	840360	128177	735299	26589	20325	910390	1750750
2001	46050	36183	80004	678123	840360	128177	735299	26589	20325	910390	1750750
2002	46050	36183	80004	678123	840360	128177	735299	26589	20325	910390	1750750
2003	46050	36183	80004	678123	840360	128177	735299	26589	20325	910390	1750750
2004	46050	36183	80004	678123	840360	128177	735299	26589	20325	910390	1750750
2005	46050	36183	73994	644066	800293	121955	699272	25432	20325	866984	1667277
2006	46050	36183	73994	644066	800293	121955	699272	25432	20325	866984	1667277
2007	46050	36183	73994	644066	800293	121955	699272	25432	20325	866984	1667277
2008	46050	36183	73994	644066	800293	121955	699272	25432	20325	866984	1667277
2009	46050	36183	73994	644066	800293	121955	699272	25432	20325	866984	1667277
2010	46050	36183	73994	644066	800293	123267	699272	24120	20325	866984	1667277
2011	46050	36183	73994	644066	800293	123490	699272	23897	20325	866984	1667277
2012	46050	36183	73981	643994	800208	123608	699195	23764	20325	866892	1667100
2013	46050	36183	73981	643994	800208	123694	699195	23678	20325	866892	1667100
2014	46050	36183	73981	643994	800208	124307	699508	23065	20012	866892	1667100
2015	46050	36183	73981	643994	800208	124471	699952	22901	19568	866892	1667100
2016	46050	36183	73981	643994	800208	124471	699952	22901	19568	866892	1667100
2017	46050	36183	73981	643994	800208	124471	699952	22901	19568	866892	1667100

year	Ajara AR, ha			Abkhazia and South Ossetia, ha	Forest areas that exist on the protected sites	Total area of forest of Georgia(12+16+17+18), thousand ha
	coniferous	deciduous	Total			
13	14	15	16	17	18	19
1990	54630	127470	182,100	624787	158316	**2752300**

105 Racha-Lechkhumi and Lower Svaneti; Imereti; Guria; part of Samegrelo-Upper Svaneti

106 Inner Kartli; Samtskhe-Javakheti; Mtskheta-Mtianeti; Lower Kartli; Kakheti

1991	54630	127470	182,100	624787	158316	**2752300**
1992	54630	127470	182100	624787	158316	**2752300**
1993	54630	127470	182100	624787	158316	**2752300**
1994	54630	127470	182100	624787	158316	**2752300**
1995	54630	127470	182100	624787	158316	**2752300**
1996	54630	127470	182100	624787	158316	**2752300**
1997	54630	127470	182100	624787	158316	**2752300**
1998	56100	130900	187000	623087	212563	**2773400**
1999	56100	130900	187000	623087	212563	**2773400**
2000	56100	130900	187000	623087	212563	**2773400**
2001	56100	130900	187000	623087	212563	**2773400**
2002	56100	130900	187000	623087	212563	**2773400**
2003	56100	130900	187000	623087	212563	**2773400**
2004	56100	130900	187000	623087	212563	**2773400**
2005	56100	130900	187000	623087	295036	**2772400**
2006	56100	130900	187000	623087	295036	**2772400**
2007	56100	130900	187000	623087	295036	**2772400**
2008	56100	130900	187000	623087	295036	**2772400**
2009	56100	130900	187000	623087	295036	**2772400**
2010	42288	106092	148380	623087	295036	**2733780**
2011	42288	106092	148380	623087	295036	**2733780**
2012	40498	99149	139647	623087	302939	**2732773**
2013	40498	99149	139647	623087	302939	**2732773**
2014	40498	99149	139647	623087	304090	**2733924**
2015	40498	99149	139647	623087	316673	**2746507**
2016	40498	99149	139647	623087	316673	**2746507**
2017	40498	99149	139647	623087	317234	**2747068**

Table 5-16 Average Annual Increment of Forest Areas in m^3/ha yr[107]

Species	West Georgia		East Georgia		Ajara AR humid subtropical climate
	humid continental climate	humid subtropical climate	dry continental climate	humid continental climate	
Coniferous	2.3	3.1	2.0	2.9	3.5
Deciduous	1.9	2.5	1.7	2.3	2.9

The *Table 5-17* provides volumes of timber and firewood annually produced in Georgia. (Source of data: Georgian Statistical Yearbook of Forestry 1990-2017).

Table 5-17 Firewood and Timber Produced (in their number, by illegal logging) in Georgia (Abkhazia and South Ossetia are not included) in 1990-2017[108]

Year	Firewood m^3	Roundwoodm^3	Total m^3	Year	Firewood m^3	Roundwoodm^3	Total m^3
1990	317845.0	79461.2	397306.2	2004	532018.0	133004.6	665022.6
1991	301994.0	75498.6	377492.6	2005	698703.0	174675.8	873378.8
1992	287633.0	71908.2	359541.2	2006	679338.0	179834.6	859172.6
1993	293214.0	73303.6	366517.6	2007	723278.0	180819.6	904097.6
1994	301936.0	75484.0	377420.0	2008	671650.0	167912.4	839562.4
1995	269810.0	67452.4	337262.4	2009	582516.0	145629.0	728145.0
1996	296590.0	74147.6	370737.6	2010	665454.0	166363.4	831817.4
1997	346109.0	84027.2	430136.2	2011	550983.0	137745.8	688728.8
1998	387242.0	96810.6	484052.6	2012	519917.0	114979.2	634896.2
1999	364759.0	91189.8	455948.8	2013	565936.0	141484.0	707420.0
2000	388129.0	97032.2	485161.2	2014	570397.0	142599.2	712996.2

[107] Unified forest inventory data,2003
[108] Georgian Statistical Yearbook of Forestry 1990-2017

Year	Firewood m³	Roundwoodm³	Total m³	Year	Firewood m³	Roundwoodm³	Total m³
2001	378790.0	94697.6	473487.6	2015	605558.0	151389.6	756947.6
2002	416652.0	104163.0	520815.0	2016	525297.0	131324.2	656621.2
2003	474705.0	118676.2	593381.2	2017	532387.0	133096.8	665483.8

5.5.1. Forest land remaining Forest land (4.A.1.)

No calculations were performed for this source category due to lack of relevant data.

5.5.2. Land converted to Forest land (4.A.2)

No calculations were performed for this source category due to lack of relevant data

5.6. Cropland (4.B)

The quantity of carbon that is accumulated on croplands depends on the kinds of crops grown, the management practices (e.g. fallow lands) and climatic conditions. Harvesting of annual crops (cereals, vegetables) takes place every year, therefore, in accordance with IPCC guidelines there is no net accumulation of biomass carbon stocks. In the case of perennial crops (fruit gardens, vineyards etc.) carbon is accumulated annually, that allows accumulation of carbon stock over the long period.

With regard to carbon stock changes in soils, those depend on operating practices on cultivable lands, in particular, ploughing of soil, drainage, use of organic and mineral fertilizers.

5.6.1. Cropland remaining Cropland (4.B.1)

a) Source-category description and calculated emissions

Conversion of areas designated for other purposes into the cropland category may affect the carbon stocks. Conversion of forest lands, grasslands, and wetlands into croplands usually causes loss in carbon stocks. However, there are exceptions - namely, when areas with scarce vegetable cover and sometimes totally denuded of biomass supply is converted into croplands causing an increase in carbon stock.

Since the calculations have been carried out according to Tier 1 methodology and the data provided in the methodology in default form may be used for all countries with moderate climate (all moderately humid or dry climates are included there), therefore the calculations have been conducted on areas of perennial crops in Georgia with the same factor. During the inventory period the areas covered with perennial crops mainly were showing a decreasing tendency, whereas values of emissions obtained as a result of carbon stock changes are given in *Table 5-18*.

Table 5-18 Changes in Carbon Stocks in the Biomass of Perennial Crops

Year	Area thousand ha	Reduction of areas compared to previous year, thousand ha	Carbon gains, thousand t C	Carbon losses, thousand t C	Net carbon stock change in cropland, thousand t C	Carbon dioxide net emissions/removals in cropland, $GgCO_2$
1990	356.6	NE	748.9	NE	748.9	2746.0
1991	352.1	4.5	739.4	9.45	730.0	2676.5
1992	334.0	18.1	701.4	38.01	663.4	2432.4
1993	333.0	1.0	699.3	2.1	697.2	2556.4
1994	332.0	1.0	697.2	2.1	695.1	2548.7
1995	307.0	25.0	644.7	52.5	592.2	2171.4
1996	285.0	22.0	598.5	46.2	552.3	2025.1
1997	278.0	7.0	583.8	14.7	569.1	2086.7
1998	252.6	25.4	530.5	53.3	477.1	1749.6

Year	Area thousand ha	Reduction of areas compared to previous year, thousand ha	Carbon gains, thousand t C	Carbon losses, thousand t C	Net carbon stock change in cropland, thousand t C	Carbon dioxide net emissions/removals in cropland, $GgCO_2$
1999	227.2	25.4	477.1	53.3	423.8	1553.8
2000	201.8	25.4	423.8	53.3	370.4	1358.4
2001	176.4	25.4	370.4	53.3	317.1	1162.6
2002	151.0	25.4	317.1	53.3	263.8	967.1
2003	125.6	25.4	263.8	53.3	210.4	771.7
2004	100.0	25.6	210.0	53.8	156.2	572.9
2005	110.0	NE	252.0	NE	252.0	924.0
2006	116.0	NE	256.2	NE	256.2	939.4
2007	114.0	2.0	239.4	4.2	235.2	939.4
2008	115.0	NE	243.6	NE	243.6	893.2
2009	114.0	1.0	239.4	2.1	237.3	870.1
2010	113.0	1.0	237.3	2.1	235.2	862.4
2011	111.0	2.0	233.1	4.2	228.9	839.3
2012	110.0	1.0	231.0	2.1	228.9	839.3
2013	110.0	NE	231.0	NE	231.0	847.0
2014	110.0	NE	231.0	NE	231.0	847.0
2015	110.0	NE	231.0	NE	231.0	847.0
2016	110.0	NE	231.0	NE	231.0	847.0
2017	120.8	NE	276.4	NE	276.4	1013.4

With regard to emissions and absorptions in croplands, in particular, in mineral soils, as we have already noted, the factors have been taken from the respective Tables of IPCC guidelines; the results obtained by the calculations are provided in *Table 5-19*.

Table 5-19 Carbon Stock Changes and CO_2 emissions/absorptions in Croplands (in mineral soils)

Land use	Area, thousand ha	Annual change in carbon stocks in mineral soils	Carbon dioxide net emissions
		thousand t C/year	$GgCO_2$/year
1990			
Cultivated	701.9	29.2	107.1
Represents temporary set aside of annually cropland	89.4	51.8	190.1
Total	791.3	81.0	297.1
1991			
Cultivated	639.7	26.6	97.6
Represents temporary set aside of annually cropland	151.6	87.9	322.3
Total	791.3	114.5	419.9
1992			
Cultivated	577.5	24.0	88.1
Represents temporary set aside of annually cropland	213.8	124.0	454.5
Total	791.3	148.0	542.6
1993			
Cultivated	515.3	21.4	78.6
Represents temporary set aside of annually cropland	276.0	160.0	586.8
Total	791.3	181.5	665.4
1994			
Cultivated	453.1	18.8	69.1
Represents temporary set aside of annually cropland	338.2	196.1	719.0
Total	791.3	214.9	788.1
1995			
Cultivated	479.4	19.9	73.1

Land use	Area, thousand ha	Annual change in carbon stocks in mineral soils	Carbon dioxide net emissions
		thousand t C/year	$GgCO_2$/year
Represents temporary set aside of annually cropland	313.2	181.6	665.8
Total	792.6	201.5	739.0
1996			
Cultivated	505.7	21.0	77.1
Represents temporary set aside of annually cropland	313.2	167.1	612.7
Total	818.9	188.1	689.8
1997			
Cultivated	532.0	22.1	81.1
Represents temporary set aside of annually cropland	263.2	152.6	559.5
Total	795.2	174.7	640.7
1998			
Cultivated	558.3	23.2	85.2
Represents temporary set aside of annually cropland	238.2	138.1	506.4
Total	796.5	161.3	591.6
1999			
Cultivated	584.6	24.3	89.2
Represents temporary set aside of annually cropland	213.2	123.6	453.2
Total	801.8	298.9	-1095.9
2000			
Cultivated	610.8	25.4	93.2
Represents temporary set aside of annually cropland	188.4	109.2	400.5
Total	799.2	134.6	493.7
2001			
Cultivated	596.6	24.8	91.0
Represents temporary set aside of annually cropland	204.4	118.5	434.5
Total	801.0	143.3	525.5
2002			
Cultivated	582.4	24.2	88.8
Represents temporary set aside of annually cropland	220.4	127.8	468.6
Total	802.8	152.0	557.4
2003			
Cultivated	568.2	23.6	86.7
Represents temporary set aside of annually cropland	236.4	137.1	502.6
Total	804.6	160.7	589.2
2004			
Cultivated	554	23.0	84.5
Represents temporary set aside of annually cropland	252.4	146.3	536.6
Total	806.4	169.4	621.1
2005			
Cultivated	539.6	22.4	82.3
Represents temporary set aside of annually cropland	268.5	155.7	570.8
Total	808.1	178.1	653.1
2006			
Cultivated	483.0	20.1	73.7
Represents temporary set aside of annually cropland	325.1	188.5	691.1
Total	808.1	208.6	764.8
2007			
Cultivated	426.4	17.7	65.0
Represents temporary set aside of annually cropland	381.7	221.3	811.5
Total	808.1	239.0	876.5
2008			
Cultivated	369.8	15.4	56.4
Represents temporary set aside of annually cropland	438.3	254.1	931.8
Total	808.1	269.5	988.2
2009			

Land use	Area, thousand ha	Annual change in carbon stocks in mineral soils	Carbon dioxide net emissions
		thousand t C/year	$GgCO_2$/year
Cultivated	313.2	13.0	47.8
Represents temporary set aside of annually cropland	494.9	286.9	1052.1
Total	808.1	300.0	1099.9
2010			
Cultivated	256.7	10.7	39.2
Represents temporary set aside of annually cropland	551.4	319.7	1172.2
Total	808.1	330.4	1211.4
2011			
Cultivated	262.4	10.9	40.0
Represents temporary set aside of annually cropland	545.7	316.4	1160.1
Total	808.1	327.3	1200.1
2012			
Cultivated	259.6	10.8	39.6
Represents temporary set aside of annually cropland	548.5	318.0	1166.1
Total	808.1	328.8	1205.7
2013			
Cultivated	310.7	12.9	47.4
Represents temporary set aside of annually cropland	497.4	288.4	1057.4
Total	808.1	301.3	1104.8
2014			
Cultivated	274.9	11.4	41.9
Represents temporary set aside of annually cropland	533.2	309.1	1133.5
Total	808.1	320.6	1175.5
2015			
Cultivated	263.7	11.0	40.2
Represents temporary set aside of annually cropland	544.4	315.6	1157.4
Total	808.1	326.6	1197.6
2016			
Cultivated	240.0	10.0	36.6
Represents temporary set aside of annually cropland	568.1	329.4	1207.7
Total	808.1	339.4	1244.4
2017			
Cultivated	220.3	9.2	33.6
Represents temporary set aside of annually cropland	587.8	340.8	1249.6
Total	808.1	350.0	1283.2

Facts of cropland liming besides 1990, have been registered in Zugdidi Municipality, namely, in the Village Kakhati the private company “Nergeta " has limed kiwi plantations in 2011-2012 and 2014-2015, in total 44 ha. Using the mentioned data, the calculations have been carried out following Tier 1 methodology and the obtained results are provided in *Table 5-20*. No such facts have been reported in recent years.

Table 5-20 CO_2, Emissions, Due to Lime Application

Year	Type of lime applied in the area	Limed area, ha	Amount of limestones applied to the area t limestones/year	Emission factor[109], tC/t limestones	Carbon emissions as a result of liming , t C/year	CO_2 emission 10^{-3} Gg/year
1990	Limestones $CaCO_3$	3000	30000	0.12	3600	13.20
2011	Limestones $CaCO_3$	14	140	0.12	17	0.06

[109] Chapter 3: LUCF Sector Good Practice Guidance, EQUATION 3.3.6. Tier 1.

Year	Type of lime applied in the area	Limed area, ha	Amount of limestones applied to the area t limestones/year	Emission factor[109], tC/t limestones	Carbon emissions as a result of liming , t C/year	CO_2 emission 10^{-3} Gg/year
2012	Limestones $CaCO_3$	10	100	0.12	12	0.04
2014	Limestones $CaCO_3$	10	100	0.12	12	0.04
2015	Limestones $CaCO_3$	10	100	0.12	12	0.04

b) Methodological issues

- ***Estimation Method***

The equation given below is the basis for the calculation of carbon accumulation and release from croplands (which do not change a land use, namely remaining cropland), in accordance with IPCC guidelines (IPCC 2003):

$$\Delta C_{CC}=\Delta C_{CCLB}+\Delta C_{CCsoils}$$

Where:

ΔC_{CC} - annual change in carbon stocks in cropland remaining cropland, tonnes C yr-1
ΔC_{CCLB} - annual change in carbon stocks in living biomass, tonnes C yr-1
$\Delta C_{CCsoils}$ - annual change in carbon stocks in soils, tonnes C yr-1

According to the methodology, areas covered with perennial crops are included in the cropland land-use category; calculation of changes in carbon stocks in the above-ground biomass is carried out for these areas. Carbon is accumulated in biomass of perennial crops, such as fruit gardens, tea plantations etc. For annual crops, increase in biomass stocks in a single year is assumed to be equal to biomass losses from harvest and mortality in that same year, thus there is no net accumulation of biomass carbon stocks.

The amount of changes in carbon stocks in biomass of perennial crops is calculated by the methodology, designed for the forest land, namely, based on the equation for estimating changes of carbon stocks, existing in forest biomass from the sub-category "remaining forest land". It should be noted here that in accordance with the IPCC guidance, unlike the forestry sector, the calculation for perennial crops is only carried out for the above-ground biomass (calculations are not conducted for the below-ground biomass).

The calculations for perennial crops have been conducted following the Tier 1 methodology, using the default factors provided by the IPCC guidelines (IPCC 2003), tailored for the climatic zones of Georgia.

The year's decrease of a biomass caused by annual decrease of areas of crops is subtracted from the year's growth of a biomass on the areas covered with perennial crops.

Regarding the calculation of CO_2 emissions and absorption in soil, it is carried out both for mineral and organic soils. In addition, losses of carbon from soils because of liming have been estimated.

Annual carbon stock changes in soils are calculated using the following formula:

$$\Delta C_{CCsoils} = \Delta C_{CCmineral} - \Delta C_{CCorganic} - \Delta C_{CClime}$$

Mineral soils

The methodology for calculations for mineral soils is based on identifying changes of carbon stocks contained in soils as a result of changes in the management of soils over a certain period.

$$\Delta C_{CCMineral} = [(SOC_0 - SOC_{(0-T)}) \times A] / T,$$

$$SOC = SOC_{REF} \times F_{LU} \times F_{MG} \times F_I,$$

Where:

$\Delta C_{CCmineral}$ -annual change in carbon stocks in mineral soils, tonnes C yr-1
SOC_0 -soil organic carbon stock in the inventory year, tons C ha-1
$SOC_{(0-T)}$ – soil organic carbon stock T years prior to the inventory, tonnes C ha-1;
T- Inventory time period, yr (default is 20 yr);
A - Land area of each parcel, ha
SOC_{REF}- the reference carbon stock, tonnes C ha-1;
F_{LU}- stock change factor for land use or land-use change type, dimensionless;
F_{MG}- stock change factor for management regime, dimensionless;

F_I- stock change factor for input of organic matter, dimensionless.

Organic Soils

According to the methodology, dried peat bed where agricultural activities take place is classified as organic soil. When organic soils are dried (peatland) and agricultural activities begin, oxidation of organic soils is stimulated in this process. That results in releasing carbon from soil (emissions).

It should be noted that peat lands are mainly located on wetlands of Western Georgia (Kolkheti national park), which are not used as agricultural cultivable lands (in their number croplands). As for agricultural wetlands, where the drainage works have started in recent years, they are presented mainly by mineral soils. It should also be noted l that in the mentioned areas the drainage works were carried out since the 60-ies of the XX century and the process was ended in the 90-ies, due to the deplorable situation that arose in the country in this period; as a result the areas underwent secondary flooding. At present the company "Georgian amelioration Ltd" (100% state owned company), is implementing rehabilitation and reconstruction of amelioration systems in the entire Georgia. On the basis of IPCC guidelines, in particular, taking into account the 20-year period of conversion (reference index), the estimated values of emissions resulted from drainage works on agricultural cultivable lands, being implemented at present, are not included in the calculations.

Liming of Croplands

Lime-containing carbonates, e.g. limestone's ($CaCO_3$), or dolomites ($CaCO_3 \times MgCO_3$) are included in the calculations. They are used in agriculture and represent a source of carbon dispersion.

The humid subtropical soils spread in Western Georgia are characterized by high acidity (pH=3.0-5.5). These soils are distinguished by physical and chemical properties unfavorable for plants, therefore there is limited normal growth of plants, assimilation of nutritional chemicals and substance exchange on these lands. On the mentioned soils the yield of annual crops as well as citruses and other perennial crops is very low, therefore liming activities are required for increasing the fertility of these soils and improving their productivity.

- ***Emission Factors***

In order to calculate carbon stock changes in perennial crops according to the IPCC methodology, the data for moderate climatic zones was taken for Georgia. In particular the accumulation rate of carbon in the above-ground biomass is 2.1 t C/ha annually, whereas on 1 ha of perennial crops 63 t of carbon is accumulated at harvest (by the methodology, this value is acceptable for both, warm humid and dry climates). Losses are calculated every year according to data, obtained because of decreasing areas covered with crops (dying or cutting of crops). In this case it is implied that the carbon stock contained earlier on the areas has been totally emitted into the atmosphere. Carbon losses (1 ha=63 t C) caused by decreasing of areas are subtracted from carbon increment in perennial crops (1 ha=2.1 t C/year). Over the given years abrupt changes has taken place in areas of perennial crops the areas covered with perennial crops decreased by 240 thousand ha - down to 110 thousand ha in 2015 as compared with 1990 data.

For calculations in croplands the reference value of carbon stock has been used (for soils), was obtained on the basis of the research carried out in Georgia ("Carbon stock in the region of Inner Kartli", Gizo Gogichaishvili). In particular, based on the research carried out in Eastern Georgia, according to the type of soil dominating on croplands in Georgia (Cambisols and Calcic Kastanozems) it has been identified that the carbon stock is 52 ton 1 ha C (soil depth 0-30 cm.). It should be noted here that by the classification of soils provided in the respective Table of the IPCC methodology, and taking into account the types of soils spread in Georgia, the reference carbon stock for Georgia is 38 t C/ha.

For mineral soils the calculations of changes of carbon stock have been made following the Tier 1 methodology, therefore the default stock change factor values have been taken from the Table[110] provided in the IPCC methodology. It should be noted that the data for cultivated lands by regions (for western relatively humid and eastern relatively dry zones) are not available. Since 70% of arable lands are located in Eastern Georgia, values for countries with dry climate were taken. As it was already mentioned the scale of changes of carbon stock in soil depends on a management regime of croplands; Therefore, appropriate stock change factor values have been chosen according to management types. Certain part of croplands in Georgia are not cultivated (*Table 5-21*) and as a result management regimes of arable lands differ from each other, therefore the calculations were carried out separately on these two types of arable lands with different management regimes. .

Table 5-21 Values of Emission Factors used in calculations

Emission Factors	**$SOC_{(0-T)}$ - soil organic carbon stock T years prior to the inventory, tonnes C ha-1;**		**SOC_0- soil organic carbon stock in the inventory year, tonnes C ha-1**	
	Cultivated	**Represents temporary set aside of annually cropland**	**Cultivated**	**Represents temporary set aside of annually cropland**
SOC_{REF}- the reference carbon stock, tons C ha	52			
F_{LU} - stock change factor for land use or land-use change type, dimensionless	0.80	0.93	0.80	0.80
F_{MG} - stock change factor for management regime, dimensionless (cultivated)	1	-	1.02	-
F_{MG} - stock change factor for management regime, dimensionless (Represents temporary set aside of annually cropland)	-	1.10	-	1
F_I - stock change factor for input of organic matter, dimensionless	1	1.37	1	1

- ***Activity Data***

The croplands and the areas covered with perennial crops in Georgia over 1990-2017 years period are distributed as presented in *Table 5-22*.

[110]AFOLU, Cropland, Table 5.5. https://www.ipcc- nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_05_Ch5_Cropland.pdf

Table 5-22 Cropland Area

Year	Total, thousand ha	Arable land,[111] thousand ha			Perennial plantations[112], thousand ha
		Total, thousand ha	Represents temporary set aside of annually cropland	Cultivated	
1990	1147.9	791.3	89.4	701.9	356.6
1991	1143.4	791.3	151.6	639.7	352.1
1992	1125.3	791.3	213.8	577.5	334.0
1993	1124.3	791.3	276.0	515.3	333.0
1994	1123.3	791.3	338.2	453.1	332.0
1995	1099.6	792.6	313.2	479.4	307.0
1996	1078.9	793.9	288.2	505.7	285.0
1997	1073.2	795.2	263.2	532.0	278.0
1998	1049.1	796.5	238.2	558.3	252.6
1999	1025.0	797.8	213.2	584.6	227.2
2000	1001.0	799.2	188.4	610.8	201.8
2001	977.4	801.0	204.4	596.6	176.4
2002	953.8	802.8	220.4	582.4	151.0
2003	930.2	804.6	236.4	568.2	125.6
2004	906.4	806.4	252.4	554.0	100.0
2005	918.1	808.1	268.5	539.6	110.0
2006	924.1	808.1	325.1	483.0	116.0
2007	922.1	808.1	381.7	426.4	114.0
2008	923.1	808.1	438.3	369.8	115.0
2009	922.1	808.1	494.9	313.2	114.0
2010	921.1	808.1	551.4	256.7	113.0
2011	919.1	808.1	545.7	262.4	111.0
2012	918.1	808.1	548.5	259.6	110.0
2013	918.1	808.1	497.4	310.7	110.0
2014	918.1	808.1	533.2	274.9	110.0
2015	918.1	808.1	544.4	263.7	110.0
2016	918.1	808.1	568.1	240.0	110.0
2017	928.9	808.1	587.8	220.3	120.8

As for liming activities, they began in Georgia in the 60-ies of the past century and mainly covered acid soils in Western Georgia. The works were carried out annually on the area of 10-12 thousand ha. Liming was renewed in Georgia every 6-7 years and it was controlled by the state. At present the facts of liming are rare and they are not accounted for appropriately. According to the available materials, liming in Georgia has been conducted in 1990 - on an area of 3000 ha and in 1992 - on an area of 500 ha[113]. Since then liming was recorded in 2011 in Zugdidi municipality. The private company "Nergeta" started kiwi plantations in the village Kakhati. During this process the company carried out liming of various intensity on its own area, namely, in 2011 it limed 14 ha, in 2012 - 10 ha and in 2014-2015 in total (10 ha annually) the company limed the area up to 20 ha.

5.6.2. Land converted to Cropland (4.B.2)

No calculations were performed for this source category due to lack of relevant data.

5.7. Grassland (4.C)

a) Source-category description and calculated emissions

[111] National Statistics Service of Georgia, http://www.geostat.ge/ ;
[112] Statistical data of UN Food and Agriculture Organization, http://www.fao.org/faostat/en/#data/RL
[113] Roza Lortkipanidze, Soils and agriculture of Imereti, Tbilisi 1997.

In accordance with the IPCC methodology Grassland comprises rangelands and pastureland that are not considered cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pasture systems, consistent with national definitions.

In this category the calculations have been conducted for the soil pool using the equation that was used for soils of arable land. The calculations have shown that the state of hay lands is stable and thus no emissions take place, whereas the areas of pastures are the source of emission.

The values obtained by calculations on grasslands of Georgia during the inventory period are provided in *Table 5-23*.

Table 5-23 Carbon Stock Changes and CO_2 emissions/removals in Grassland

Land use	**Area, thousand ha**	**Annual change in carbon stocks in mineral soils**	**Carbon dioxide emissions**
		thousand t C/year	**$GgCO_2$/year**
1990			
Grassland	1826.0	-892.6	-3272.8
Hayland	130.0	101.4	371.8
Total	1956.0	-791.2	-2901.0
1991			
Grassland	1830.0	-892.6	-3272.8
Hayland	131.0	101.4	371.8
Total	1961.0	-791.2	-2901.0
1992			
Grassland	1835.0	-896.9	-3288.5
Hayland	132.0	103.0	377.5
Total	1967.0	-793.9	-2911.0
1993			
Grassland	1838.0	-897.0	-3289.0
Hayland	134.0	104.5	383.2
Total	1972.0	-792.5	-2905.8
1994			
Grassland	1842.0	-900.4	-3301.4
Hayland	135.0	105.3	386.1
Total	1977.0	-795.1	-2915.3
1995			
Grassland	1842.3	-900.5	-3301.7
Hayland	135.8	105.9	388.4
Total	1978.1	-794.5	-2913.3
1996			
Grassland	1843.1	-900.8	-3303.1
Hayland	136.6	106.5	390.7
Total	1979.7	-794.3	-2912.4
1997			
Grassland	1843.9	-901.2	-3304.4
Hayland	137.4	107.2	393.0
Total	1981.3	-794.0	-2911.4
1998			
Grassland	1844.7	-901.6	-3305.7
Hayland	138.2	107.8	395.3
Total	1982.9	-793.8	-2910.5
1999			
Grassland	1845.5	-901.9	-3307.1
Hayland	139.0	108.4	397.5
Total	1984.5	-793.5	-2909.5

Land use	Area, thousand ha	Annual change in carbon stocks in mineral soils	Carbon dioxide emissions
		thousand t C/year	$GgCO_2$/year
		2000	
Grassland	1846.4	-902.5	-3309.2
Hayland	139.0	108.4	397.54
Total	1985.4	-794.1	-2911.7
		2001	
Grassland	1846.0	-902.5	-3309.0
Hayland	139.0	109.2	400.4
Total	1985.0	-793.3	-2908.6
		2002	
Grassland	1848.6	-903.7	-3313.5
Hayland	141.1	110.1	403.5
Total	1989.7	-793.6	-2910.0
		2003	
Grassland	1849.7	-904.2	-3315.6
Hayland	141.6	110.4	405.0
Total	1991.3	-793.8	-2910.6
		2004	
Grassland	1850.8	-904.8	-3317.6
Hayland	142.1	110.8	406.4
Total	1992.9	-794.0	-2911.2
		2005	
Grassland	1851.9	-905.4	-3319.6
Hayland	142.6	111.2	407.8
Total	1994.5	-794.1	-2911.8
		2006	
Grassland	1853.3	-905.9	-3321.7
Hayland	143.2	111.7	409.5
Total	1996.5	-794.2	-2912.1
		2007	
Grassland	1853.3	-905.9	-3321.7
Hayland	143.2	111.7	409.5
Total	1996.5	-794.2	-2912.1
		2008	
Grassland	1853.3	-905.9	-3321.7
Hayland	574.5	111.7	409.5
Total	2427.8	-794.2	-2912.1
		2009	
Grassland	1853.3	-905.9	-3321.7
Hayland	143.2	111.7	409.5
Total	1996.5	-794.2	-2912.1
		2010	
Grassland	1853.3	-905.9	-3321.7
Hayland	143.2	111.7	409.5
Total	1996.5	-794.2	-2912.1
		2011	
Grassland	1853.3	-905.9	-3321.7
Hayland	143.2	111.7	409.5
Total	1996.5	-794.2	-2912.1
		2012	
Grassland	1853.3	-905.9	-3321.7
Hayland	143.2	111.7	409.5
Total	1996.5	-794.2	-2912.1
		2013	
Grassland	1853.3	-905.9	-3321.7
Hayland	143.2	111.7	409.5

Land use	Area, thousand ha	Annual change in carbon stocks in mineral soils	Carbon dioxide emissions
		thousand t C/year	$GgCO_2$/year
Total	1996.5	-794.2	-2912.1
2014			
Grassland	1853.3	-905.9	-3321.7
Hayland	143.2	111.7	409.5
Total	1996.5	-794.2	-2912.1
2015			
Grassland	1853.3	-905.9	-3321.7
Hayland	143.2	111.7	409.5
Total	1996.5	-794.2	-2912.1
2016			
Grassland	1853.3	-905.9	-3321.7
Hayland	143.2	111.7	409.5
Total	1996.5	-794.2	-2912.1
2017			
Grassland	1853.3	-905.9	-3321.7
Hayland	143.2	111.7	409.5
Total	1996.5	-794.2	-2912.1

Since information about areas converted into grasslands from other land-use categories (forest lands, wetlands etc.) for the inventory is not available, the calculations were not conducted in this case. It should be noted, however, that in Georgia there are no facts of large-scale conversion of various categories of areas into grasslands; neither large-scale misappropriation of areas (for future use as pastures) have occurred.

Methodological issues

- ***Estimation Method***

The below-ground carbon stocks prevail on grasslands. The carbon stock is accumulated mainly in the root system and organic mass of soil.

The carbon stock contained in grasslands is affected by anthropogenic activity and natural phenomena. Annual accumulation of biomass on grasslands may result in high volumes, but due to rapid losses (grazing, mowing, fires etc.) the grasslands become the source of emission.

The calculations have been carried out following the Tier 1 methodology. In this case the methodology defines that calculations are carried out only on carbon stocks contained in the soil. Taking this into account, the calculation has been carried out correspondingly, by the equation[114] used for croplands, but the factors have been taken from the Table[115] designated for grasslands.

Despite the fact that grasslands and hay lands are included jointly in this land-use category, , the regimes of their management radically differ from each other. Thus, calculations of carbon stock changes in soils implied for grasslands and hay lands have been carried out separately.

Mineral soils

The formula for calculation of changes in carbon stocks in mineral soils is given below:

$$\Delta C_{GGMineral} = [(SOC_0 - SOC_{(0-T)}) \times A] / T,$$

$$SOC = SOC_{REF} \times F_{LU} \times F_{MG} \times F_I,$$

[114]http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html(equi. 3.3.3.)

[115] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_06_Ch6_Grassland.pdf , TABLE 6.2

Where:

$\Delta C_{GGMineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr-1
SOC_0 = soil organic carbon stock in the inventory year, tons C ha-1
$SOC_{(0-T)}$= soil organic carbon stock T years prior to the inventory, tonnes C ha-1
T = inventory time period, yr (default is 20 yr)
A= land area of each parcel, ha
SOC_{REF} = the reference carbon stock, tonnes C ha-1;
F_{LU} = stock change factor for land use or land-use change type, dimensionless;
F_{MG} = stock change factor for management regime, dimensionless;
F_I = stock change factor for input of organic matter, dimensionless.

Organic soils

Calculations on grasslands and hay lands existing on organic soils are usually carried out when drainage works are carried out. In Georgia, the drainage works on wet grasslands and hay lands are not conducted, therefore the calculations were not made.

It should also be noted, that due to unavailability of data for liming of grasslands and hay lands (areas of limed grasslands) the calculations were not conducted for this category.

- ***Emission Factors***

Since the calculations for soils have been carried out mainly following the Tier 1 approach, the significant part of Emission Factors has been taken from the Table 6.2 provided in the methodology:[116]. With regard to the value of the reference carbon stock for grasslands, similarly to croplands the data have been taken from research conducted in Georgia and it equals to 52 t C/ha.

Since an essential degradation of grasslands is noted in Georgia, a stock change factor corresponding to abrupt degradation has been taken for Eastern Georgia[117] for the regime of areas management (F_{MG}), and a factor envisaged for average degradation - for Western Georgia.

Hay lands as compared to grasslands undergo less degradation and therefore their state is more stable. Respectively, different factors (of less degradation) have been applied for them (*Table 5-24*).

Table 5-24 Emission Coefficients Used in Calculations (grassland -1990)

Emission Factors	$SOC_{(0-T)}$ - soil organic carbon stock T years prior to the inventory, tons C ha-1;		SOC_0- soil organic carbon stock in the inventory year, tons C ha-1	
	West Georgia, temperate warm, humid	East Georgia, temperate warm and dry	West Georgia, temperate warm, humid	East Georgia, temperate warm and dry
SOC_{REF}- the reference carbon stock, tons C ha	52			
F_{LU} - stock change factor for land use or land-use change type	1	1	1	1
F_{MG} - stock change factor for management regime	1	1	0.95	0.70
F_I - stock change factor for input of organic matter	1	1	1	1

[116]AFOLU, https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_06_Ch6_Grassland.pdf ,GRASSLAND, Table 6.2.
[117] http://www.moe.gov.ge/ka/%E1%83%97%E1%83%94%E1%83%9B%E1%83%94%E1%83%91%E1%83%98/mica

- ***Activity Data***

The distribution of grasslands and hay lands in Georgia is provided in *Table 5-25*. Since the condition of grasslands (in contrast to hay lands) on the territories of Western and Eastern Georgia drastically differs from each other (the grasslands of Eastern Georgia undergo intense degradation), therefore, in order to increase the accuracy, calculations were carried out separately for Western and Eastern Georgia.

Table 5-25 Areas of Grasslands and Hay Lands

Years	Total, thousand ha	Hayland, thousand ha	Grassland, thousand ha		
			Total, thousand ha	Temperate warm, humid	Temperate warm, dry
1990	1956.5	130.0	1826.5	566.2	1260.3
1991	1961.5	131.2	1830.3	567.4	1262.9
1992	1966.6	132.5	1834.1	568.6	1265.5
1993	1971.6	133.7	1837.9	569.8	1268.1
1994	1976.5	135.0	1841.5	570.9	1270.6
1995	1978.1	135.8	1842.3	571.2	1271.1
1996	1979.7	136.6	1843.1	571.5	1271.6
1997	1981.3	137.4	1843.9	571.8	1272.1
1998	1982.9	138.2	1844.7	572.1	1272.6
1999	1984.5	139.0	1845.5	572.4	1273.1
2000	1986.5	140.1	1846.4	572.3	1274.1
2001	1988.1	140.6	1847.5	572.6	1274.9
2002	1989.7	141.1	1848.6	572.9	1275.7
2003	1991.3	141.6	1849.7	573.2	1276.5
2003	1992.9	142.1	1850.8	573.5	1277.3
2004	1994.5	142.6	1851.9	573.8	1278.1
2005	1996.5	143.2	1853.3	574.5	1278.8
2006	1996.5	143.2	1853.3	574.5	1278.8
2007	1996.5	143.2	1853.3	574.5	1278.8
2008	1996.5	143.2	1853.3	574.5	1278.8
2009	1996.5	143.2	1853.3	574.5	1278.8
2010	1996.5	143.2	1853.3	574.5	1278.8
2011	1996.5	143.2	1853.3	574.5	1278.8
2012	1996.5	143.2	1853.3	574.5	1278.8
2013	1996.5	143.2	1853.3	574.5	1278.8
2014	1996.5	143.2	1853.3	574.5	1278.8
2015	1996.5	143.2	1853.3	574.5	1278.8
2016	1996.5	143.2	1853.3	574.5	1278.8
2017	1996.5	143.2	1853.3	574.5	1278.8

5.7.1. Grassland remaining Grassland (4.C.1)

No calculations were performed for this source category due to lack of relevant data.

5.7.2. Land converted to Grassland (4.C.2)

No calculations were performed for this source category due to lack of relevant data.

5.8. Wetlands (4.D)

5.8.1. Wetlands remaining Wetlands (4.D.1)

Wetlands, in their number marshes, in Georgia due to specific landscape and climatic conditions are mainly presented in Kolkheti and Javakheti, though it should be noted, that despite high anthropogenic impact, the fragments and habitats of watery areas are also preserved in Eastern Georgia. In total, wetlands cover 51,500 ha of Georgian territory. The areas of wetlands are provided in *Table 5-26*.

Table 5-26 Wetlands

Major lakes	
Name	**Ha**
Bazaleti	122
Lisi	47
Paliastomi	1820
Ritsa	149
Saghamo	481
Tabatskuri	1420
Paravani	3750
Khozafin, Kartsakhi	2630
Jandar	1250
Khadik	14
Santi	73
Chanchal	1330
Madatap	878
Keli	128
Tobavarchkhili	21
Grdzeli	17
Ertso	31
Kochebis	38
Mrude	26
Abulis	90
Bugdasheni	39
Paskias	177
Bareti	124
Didi gldani	20
Total	**14675**
Major reservoirs, ha	
Name	**Ha**
Gali	803
Enguri	1350
Jinvali	1150
Samgori	1180
Sioni	1200
Tkibuli	1150
Shaori	1320
Tsalka	3370
Vartsikhe	510
Gumati	240
Algeti	230
Lajanuri	160
Nadarbazevi	118
Zonkari	140
Total	**12921**
Total lakes and reservoirs	**27596**

Swamps	**51500**
Total (Major lakes, reservoirs and swamps)	**79096**
Other internal water fund	**76,604**
Black Sea territorial waters of Georgia	679400
SUM	**835100**

5.8.2. Land converted to Wetlands (4.D.2)

No calculations were performed for this source category due to lack of relevant data.

5.9. Settlements (4.E)

5.9.1. Settlements remaining Settlements (4.E.1)

Since the data needed for calculations (such as: areas covered by timber plants (ha) in all settlements (cities, villages and settlements), in all years, as well as the volume of annual accumulation of carbon in the mentioned crops (t C/year), and average age of woody plants in composition of cover (year)),were not available in Georgia, the calculations were not conducted. Only limited data on planting provided in the sustainable energy action plans for several self-governed cities are available, which is not sufficient to represent and reflect the general situation in Georgia.

Table 5-27 Settlements

Settlements, thousand ha		**88.4**
E.g. Major cities		
	Population (year)	Area, ha
Tbilisi	1 118 300 (2015)	50200
Batumi	152 839 (2015)	1937
Kutaisi	147 635 (2015)	5600
Kutaisi	125 103 (2015)	6000
Gori	49 700 (2015)	2320
Zugdidi	42 998 (2015)	2180
Rustavi	19 629(2015)	1963
Poti	41 465 (2015)	6900
	Total	77100
Infrastructure, thousand ha		**122.8**
E.g. Highways		
	Length, km	Area, ha
Of international significance	1595.0	15950.0
Of domestic importance	5372.6	37608.2
Total	6967.6	53558.2
E.g. Area covered by railway tracks		
Length of main rails	1441.7	4,325.0
	Total	57,883
Total settlements and infrastructure, thousand ha		**211.2**

5.9.2. Land converted to Settlements (4.E.2)

No calculations were performed for this source category due to lack of relevant data.

5.10. Other land (4.F)

According to the IPCC methodology, calculations are not conducted for this category, since it is considered that normally these are unmanaged areas. As for the lands converted into the other land category (forest lands, wetlands etc.) there is lack of the statistical data in Georgia on such conversions, , consequently carbon stock change estimation for these land-use conversion category has not been conducted.

5.10.1. Other land remaining Other land (4.F.1)

No calculations were performed for this source category due to lack of relevant data.

5.10.2. Land converted to Other land (4.F.2)

No calculations were performed for this source category due to lack of relevant data.

5.11. Harvested Wood Products (4.G)

No calculations were performed for this source category due to lack of relevant data.

5.11.1. Buildings

No calculations were performed for this source category due to lack of relevant data.

5.11.2. Wood used for other than buildings

No calculations were performed for this source category due to lack of relevant data.

5.11.3. Paper and paperboard

No calculations were performed for this source category due to lack of relevant data.

5.12. Direct N_2O emissions from N inputs to managed soils (4. (I))

No calculations were performed for this source category due to lack of relevant data.

5.13. Emissions and Removals from Drainage and Rewetting and Other Management of Organic and Mineral soils (4.(II))

No calculations were performed for this source category due to lack of relevant data.

5.14. Direct N_2O emissions from N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils (4.(III))

No calculations were performed for this source category due to lack of relevant data.

5.15. Indirect nitrous oxide (N_2O) emissions from managed soils (4.(IV))

No calculations were performed for this source category due to lack of relevant data.

5.16. Biomass burning (4.(V))

The calculations for this source category, based on currently available data, were only carried out in the forest land section. In particular, the magnitude of CO_2 and other greenhouse gas emissions from biomass combustion during forest fires was estimated by years (*Table 5-6*).

Chapter 6. Waste (CRF Sector 5)

6.1. Overview of Sector

Waste Management is still an environmental challenge for Georgia - poor waste management leads to one of the most important environmental problems.

Georgia makes efforts to improve the situation. In 2015 Solid Waste Management Code of Georgia entered into force. The Code aimed at establishing a legal framework in the field of solid waste management for implementing measures that will facilitate waste prevention and its increased re-use as well as environmentally safe treatment of waste (which includes recycling and separation of secondary raw materials, energy recovery from waste and safe disposal of waste).

Solid Waste Management Company of Georgia (SWMCG) intends to construct new regional landfills and systems of connected transfer stations to assure a fully integrated solid waste management system in Georgia in the future. The core mission of SWMCG is to replace all former municipal landfills over the period of about 10 years with a system of regional landfills and a network of connected transfer stations. A certain number of former municipal landfills will be closed, and some of them will be transformed into transfer stations.

Untreated municipal wastewater is a major cause of surface water pollution in Georgia. Water used in households and industry contains a huge amount of toxins that gravely degrade the natural environment, flora and fauna, and the quality of life of the population.

The centralized sewage system exists in 45 towns in Georgia. The systems are, however, in poor condition. The plants are typically 30-45 years old; some are still uncompleted, and most them are not maintained. Most of the wastewater treatment plants cannot provide sewage treatment with high efficiency. None of the existing plants (excluding Adlia plant) provide actual biological treatment since the technical facilities are out of order.

In Adlia treatment plant wastewater is cleaned in several mechanical and chemical stages. At primary mechanical cleaning stage wastewater is cleaned of sand, fat and residue. Silt is collected and stabilized. At biological cleaning stage ammonium transforms into nitrate and protein and hydrocarbons are reduced. At secondary mechanical cleaning silt is removed.

The estimated GHG emissions from waste sector are provided in *Table 6-1* and *Table 6-2*

Table 6-1 Methane and Nitrous Oxide emissions (in Gg) from Waste sector in 1990-2017

Year	CH_4				N_2O
	Solid Waste Disposal Sites (5.A)	Domestic W/W Handling (5.D.1)	Industrial W/W Handling (5.D.2)	Total	Domestic W/W Handling
1990	31.15	11.45	8.84	51.44	0.18
1991	32.78	11.5	5.83	50.11	0.18
1992	34.27	11.48	4.47	50.22	0.18
1993	35.63	11.22	3.34	50.19	0.19
1994	36.94	10.29	1.96	49.19	0.19
1995	38.18	9.99	2.52	50.69	0.19
1996	39.27	9.71	3.12	52.10	0.19
1997	40.25	9.46	3.76	53.47	0.18
1998	41.13	9.32	4.32	54.77	0.18
1999	41.97	9.23	4.99	56.19	0.19
2000	42.95	9.14	5.59	57.68	0.19

Year	CH_4				N_2O
	Solid Waste Disposal Sites (5.A)	Domestic W/W Handling (5.D.1)	Industrial W/W Handling (5.D.2)	Total	Domestic W/W Handling
2001	43.82	9.06	5.78	58.66	0.18
2002	44.59	8.99	5.87	59.45	0.18
2003	45.28	8.87	6.05	60.20	0.18
2004	45.94	8.74	6.3	60.98	0.19
2005	46.62	8.61	6.53	61.76	0.18
2006	47.33	8.49	7.04	62.86	0.18
2007	48.14	8.36	7.5	64.00	0.18
2008	48.94	8.23	7.91	65.08	0.18
2009	49.71	8.19	8.8	66.70	0.18
2010	50.37	8.13	9.46	67.96	0.18
2011	50.68	8.08	10.45	69.21	0.18
2012	51.93	8	10.66	70.59	0.18
2013	52.29	7.96	10.51	70.76	0.18
2014	52.59	7.95	10.6	71.14	0.18
2015	52.80	7.97	10.91	71.68	0.18
2016	53.00	7.98	10.47	71.45	0.19
2017	53.17	7.97	10.42	71.56	0.19

Table 6-2 Methane and Nitrous Oxide emissions (in Gg CO_2eq) from Waste sector in 1990-2017 years

Year	Solid Waste Disposal Sites-CH_4	Domestic W/W Handling-CH_4	Industrial W/W Handling-CH_4	Domestic W/W Handling-N_2O	Total
1990	654	240	186	55	**1,135**
1991	688	241	122	55	**1,106**
1992	720	241	94	55	**1,110**
1993	748	236	70	58	**1,112**
1994	776	216	41	58	**1,091**
1995	802	210	53	60	**1,125**
1996	825	204	66	58	**1,153**
1997	845	199	79	57	**1,180**
1998	864	196	91	57	**1,208**
1999	881	194	105	57	**1,237**
2000	902	192	117	58	**1,269**
2001	920	190	121	57	**1,288**
2002	936	189	123	57	**1,305**
2003	951	186	127	57	**1,321**
2004	965	184	132	58	**1,339**
2005	979	181	137	57	**1,354**
2006	994	178	148	56	**1,376**
2007	1,011	176	158	55	**1,400**
2008	1,028	173	166	54	**1,421**
2009	1,044	172	185	55	**1,456**
2010	1,058	171	199	55	**1,483**
2011	1,064	170	220	55	**1,509**
2012	1,090	168	224	56	**1,538**
2013	1,098	167	221	56	**1,542**
2014	1,104	167	223	57	**1,551**
2015	1,109	167	229	57	**1,562**
2016	1,113	168	220	58	**1,559**
2017	1,117	167	219	59	**1,562**

The shares of different source categories in waste sector emissions are presented in *Table 6-3*. Methane emissions from Solid Waste Disposal Sites are dominant.

Table 6-3 Share of different source categories in GHG emissions from waste sector

Year	Solid Waste Disposal Sites-CH_4	Domestic W/W Handling-CH_4	Industrial W/W Handling-CH_4	Domestic W/W Handling-N_2O	Total
1990	56	22	17	5	100
1991	61	22	11	5	100
1992	64	22	9	5	100
1993	66	22	7	5	100
1994	70	20	4	5	100
1995	70	19	5	5	100
1996	71	18	6	5	100
1997	71	17	7	5	100
1998	71	17	8	5	100
1999	70	16	9	5	100
2000	70	16	10	5	100
2001	71	15	10	5	100
2002	71	15	10	4	100
2003	71	14	10	4	100
2004	71	14	10	4	100
2005	71	14	10	4	100
2006	71	13	11	4	100
2007	71	13	12	4	100
2008	72	13	12	4	100
2009	71	12	13	4	100
2010	71	12	14	4	100
2011	70	11	15	4	100
2012	70	11	15	4	100
2013	70	11	15	4	100
2014	70	11	15	4	100
2015	70	11	15	4	100
2016	71	11	15	4	100
2017	71	11	14	4	100

Comparison of recalculated GHG emissions with relevant values from SBUR

For 1990, 1994, 2000, 2005, 2011-2015 years the recalculated values have been compared with relevant values from Second Biennial Update Report (SBUR). Differences are provided in *Table 6-4*. According to this table the difference between FNC and SBUR varies within the range of 0%-10%. Solid Waste Disposal Sites reflect the most significant difference among the categories. Differences are caused mainly due to application of specified activity data. In case of SWDS delay in time was taken into account.

Table 6-4 Difference (in %) between FNC and Second BUR

Year	CH4 / Solid Waste Disposal Sites	Previous inventories (SBUR)	Difference, in %	CH4 / Domestic Waste Water Handling	Previous inventories (SBUR)	Difference, in %	CH4 / Industrial Waste Water	Previous inventories (SBUR)	Difference, in %	N_2O / Domestic Waste Water Handling	Previous inventories (SBUR)	Difference, in %	CO_2-eq emissions from Waste sector	Previous inventories (SBUR)	Difference, in %
1990	654	558	17	240	227	6	186	263	-29	55	57	-4	**1,135**	**1,105**	**3**
1994	776	663	17	216	218	-1	41	42	-3	58	54	7	**1,091**	**977**	**12**
2000	902	764	18	192	191	0	117	117	0	58	53	9	**1,269**	**1,125**	**13**
2005	979	824	19	181	183	-1	137	139	-2	57	54	6	**1,354**	**1,200**	**13**
2010	1,058	881	20	171	183	-7	199	211	-6	55	55	0	**1,483**	**1,330**	**11**
2011	1,064	891	19	170	183	-7	220	233	-6	55	55	0	**1,509**	**1,362**	**11**
2012	1,090	893	22	168	181	-7	224	246	-9	56	55	2	**1,538**	**1,375**	**12**
2013	1,098	894	23	167	181	-8	221	244	-10	56	56	0	**1,542**	**1,375**	**12**
2014	1,104	895	23	167	183	-9	223	243	-8	57	57	0	**1,551**	**1,378**	**13**
2015	1,109	894	24	167	183	-9	229	253	-10	57	58	-2	**1,562**	**1,388**	**13**
2016	1,113			168			220			58			**1,559**		
2017	1,117			167			219			59			**1,562**		

6.2. Solid Waste Disposal (5.A.)

Presently there are 56 municipal landfills in Georgia. Solid Waste Management Company of Georgia manages 53 landfills, 2 landfills are managed by Municipality of Batumi city in Adjara Autonomous Republic and Didi Lilo landfill is managed by Tbilisi municipality.

The methane emissions from landfills in Georgia are estimated based on the IPCC First order decay (FOD) method. The IPCC FOD method assumes that the degradable organic component/degradable organic carbon (DOC) in waste decays slowly throughout a few decades, during which CH4 and CO2 are produced.

IPCC First order decay (FOD) method:

According to the 2006 IPCC "The FOD method requires data to be collected or estimated for historical disposals of waste over a time period of 3 to 5 half-lives in order to achieve an acceptably accurate result". This requirement is fulfilled for majority of landfills.

$$CH_{4generated,t} = \{DDOCm_t \times [1 - exp(-k)] + H_{t-1} \times [1 - exp(-k)]\} \times 16/12 \times F_t$$

$$H_t = DDOCm_t \times \exp(-k) + H_{t-1} \times \exp(-k), \qquad H_0 = 0$$

$$DDOCm_t = W_t \times DOC_t \times DOCF_t \times MCF_t$$

Production of CH4 does not begin immediately after disposal of the waste.

DDOCm decomp = DDOCm0 x {1 – exp[-k x DL) / 12] }

Where

DL- time delay in months

$$W_t = Pop_t \times GR_t \times MSW_{F,t}$$

Where:

$CH_{4\,generated,t}$	CH_4 generated in year t
t	year of inventory
$DDOC_{mt}$	mass of decomposable DOC deposited in year t (Gg)
$k=ln(2)/t_{1/2}$	methane generation rate constant
$t_{1/2}$	half life
F_t	fraction by volume of CH_4 in landfill gas
DOC_t	degradable organic carbon in year t
$DOC_{F,t}$	fraction of DOC dissimilated in year t
MCF_t	methane correction factor in year t
W_t	amount of waste deposited in landfills in year t
Pop_t	population whose waste goes to SWDS (habitants)
GR_t	MSW generation rate in year t (kg per capita)
$MSW_{F,t}$	fraction of MSW disposed at SWDS in year t

Activity data:

Solid Waste Management Company of Georgia is the source of data on the amount of waste annually deposited in landfills.

Methane Recovery

Methane recovery from landfills is not practiced in Georgia.

MSW generation rate in year t (kg per capita)

The following values are used for the calculatios: 2006 IPCC default value for Eastern Europe (1.04 kg/capita/day) for 2000-2017 years, 0.85 kg/capita/day (1996 IPCC, Generation rate for Greece) for years prior to 1990 and linear interpolated values for years 1991-1999.

Fraction of MSW disposed to SWDS

The following values are used: 2006 IPCC default value for Eastern Europe MSW_F = 0.9 for 2000-2017 years, 0.93 for years before 1990 (1996 IPCC, MSWF for Greece, nearby comparable country) and linear interpolated values for 1991-1999 years.

Methane correction factor (MCF)

MCF accounts for the fact that unmanaged SWDS produce less CH_4 from a given amount of waste than managed SWDS, since a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS.

Table 6-5 MCF default values for different types of landfills

Landfill type	MCF default values
Managed	1.0
Unmanaged – deep (>5 m)	0.8
Unmanaged – shallow (<5 m)	0.4
Non categorized	0.6

Solid waste composition: There is very scare information about the composition of solid waste disposed in landfills of Georgia. Since 2014 waste composition has been determined for several landfills. Data in *Table 5-6* are provided by Solid Waste Management Company of Georgia. Default values for Eastern Europe from the 2006 IPCC are used for other landfills.

Table 6-6 Solid waste composition

Component /Landfill	Tbilisi	Rustavi	Batumi	Kutaisi	Others
Food waste	71	42	41.2	47	30.1
Paper/cardboards	5.6	17	17.4	10	21.8
Textiles	3.2		3.3		4.7
Wood	2.6		0.5		7.5
Rubber/leather					1.4
Other	17.6	41	37.6	43	34.5

Degradable organic carbon (DOC) is the portion of organic carbon present in solid waste that is susceptible to biochemical decomposition[118]. Data from laboratory experiments conducted by Dr.Barlaz[119] are used for DOC values of specific materials Experiments provided data on the amount of CH_4 generated by each type of organic material. DOC for waste components ($DOC^k_{100\%}$) is presented in *Table 6-7*. Data

[118] DOC and DOC_f have been estimated based on “Methodology for estimating of DOC and DOCF”. Methodology was examined and approved within the UNDP/GEF Regional Project RER/01/G31” Capacity Building for Improving National GHG Inventories” (Attachment 12 to the Georgia’s National Project Report)”.

[119] M.A.Barlaz. 1997. “Biodegradative Analysis of Municipal Solid Waste in Laboratory-Scale Landfills”, EPA 600/R-97-071. Solid Waste Management and Greenhouse Gases. A Life-Cycle Assessment of Emissions and Sinks. 2nd EDITION. EPA 530-R-02-006.

from this table are used in calculations of DOC containing in k component (DOC^k_p) of waste and DOC in total.

$$DOC_p^k = DOC_{100\%}^k \times \frac{P}{100}; \quad DOC = \sum_k DOC_p^k$$

Table 6-7 Estimated DOC for solid waste disposed on landfills

Component /Landfill	Tbilisi	Rustavi	Batumi	Kutaisi	Others
DOC	0.146	0.126	0.145	0.105	0.188

Table 6-8 Details of DOC estimation (case of other landfills)

Component	Dry-wet Ratio	$DOC^k_{100\%}$		Waste composition, %	DOC^k_p
		Dry	wet		
	A	B	C=A*B	D	E=C*D/100
Second Food	0.300	0.458	0.137	30.1	0.0414
Broad Definition for Mixed Paper	0.945	0.425	0.402	21.8	0.0876
Textiles	0.900	0.550	0.495	4.7	0.0233
Wood	0.800	0.492	0.394	7.5	0.0295
Leather	0.800	0.600	0.480	1.4	0.0067
Other				34.0	
$\sum_k DOC^k_p$				100	**0.1884**

Fraction of degradable organic carbon dissimilated (DOC_F) is the portion of DOC that is converted to landfill gas. It is a good practice to use a value of 0.5 – 0.6 (including lignin C) as the default. According to GPG, national values for DOC_F can be used, but they should be based on well-documented research. For the maximum digestibility of lignocellulosic materials a log-linear relationship of Van Soest and data from Barlaz's experiment were used. DOC_F for mix of materials (municipal solid waste) was calculated by formula:

$$DOC_F = \sum_k \frac{(DOC_k \times DOC_{Fk})}{DOC}$$

Table 6-9 Estimated DOC_F for solid waste disposed on landfills

Component /Landfill	Tbilisi	Rustavi	Batumi	Kutaisi	Others
DOC_F	0.627	0.581	0.573	0.616	0.521

Table 6-10 Details of DOC_F estimation (case of other landfills)

	DOC_i	DOC_{Fi}	DOC_i*DOC_{Fi}	DOC_F
Second Food	0.0414	0.7010	0.0290	
Broad Definition for Mixed Paper	0.0876	0.4800	0.0420	
Textiles	0.0233	0.5500	0.0128	
Wood	0.0295	0.3600	0.0106	
Leather	0.0067	0.5500	0.0037	
Σ	0.1884		0.0981	**0.5208**

Fraction of CH_4 in landfill gas (F):

The Extended Buswell Equation[120] was used for calculating the fraction of volume of CH_4 in landfill gas

[120] Buswell A.M., Hatfield W.D. (ed.) (1937): Anaerobic Fermentations. State of Illinois, Department of Registration and Education, Bulletin No. 32.

Table 6-11 Estimated fraction of CH_4 in landfill gas

Component /Landfill	Tbilisi	Rustavi	Batumi	Kutaisi	Others
Fraction of CH_4 in landfill gas	0.537	0.531	0.532	0.535	0.531

Half life (t1/2):

The half-life value is the time taken for the DOCm in waste to decay to half its initial mass. k = ln(2)/t1/2. For cities located in Western Georgia k=0.09 (t1/2=7.7) and for cities in Eastern Georgia k=0.06 (t1/2=11.55).

Time delay:

It is supposed that CH4 production will begin 6 months after waste disposal, i.e. DL = 6 months.

The estimated methane emissions

Estimated methane emissions from the SWDSs of Georgia are provided in Table 6-12.

Table 6-12 Methane emissions from SWDSs of Georgia

Year	Tbilisi				Kutaisi	Rustavi		Batumi	Gori	Poti	Zygdidi		Hypothetic		GHG emissions	
	Didi Lilo	Gldani (closed)	Iagludji (closed)	Lilo (closed)		Closed	New				Closed	New	I (MCF=0.4)	II (MCF=0.8)	$GgCH_4$	$GgCO_2eq$
1990		13.33	2.43	0.35	4.11	1.84		3.46	0.38	0.89			3.82	0.55	31.15	654
1991		13.69	2.86	0.57	4.21	1.89		3.54	0.43	0.91			4.07	0.60	32.78	688
1992		14.03	3.29	0.78	4.30	1.86		3.63	0.49	0.93			4.31	0.64	34.27	720
1993		14.35	3.72	0.98	4.40	1.75		3.73	0.54	0.94			4.55	0.67	35.63	748
1994		14.62	4.13	1.18	4.49	1.65		3.84	0.59	0.96			4.77	0.70	36.94	776
1995		14.84	4.51	1.39	4.59	1.56		3.95	0.64	0.97			4.99	0.73	38.18	802
1996		15.03	4.86	1.59	4.68	1.46		4.04	0.68	0.99			5.19	0.76	39.27	825
1997		15.18	5.17	1.78	4.75	1.38		4.12	0.73	1.00			5.37	0.78	40.25	845
1998		15.30	5.44	1.96	4.82	1.30		4.18	0.77	1.01			5.55	0.80	41.13	864
1999		15.40	5.70	2.12	4.88	1.22		4.24	0.80	1.03			5.73	0.84	41.97	881
2000		15.49	5.95	2.27	4.93	1.15		4.31	0.83	1.03	0.16		5.90	0.91	42.95	902
2001		15.57	6.19	2.42	4.97	1.08		4.36	0.86	1.04	0.27		6.09	0.97	43.82	920
2002		15.64	6.40	2.55	4.99	1.02		4.41	0.88	1.05	0.37		6.26	1.03	44.59	936
2003		15.70	6.61	2.67	4.99	0.96		4.45	0.90	1.06	0.45		6.41	1.08	45.28	951
2004		15.93	6.80	2.65	4.99	0.91		4.47	0.92	1.07	0.53		6.55	1.13	45.94	965
2005		16.33	6.98	2.50	4.97	0.85		4.49	0.94	1.08	0.60		6.71	1.17	46.62	979
2006		16.71	7.16	2.35	4.95	0.80		4.50	0.97	1.08	0.67		6.91	1.22	47.33	994
2007		17.06	7.36	2.21	4.93	0.76		4.52	0.99	1.09	0.74		7.19	1.30	48.14	1,011
2008		17.41	7.55	2.08	4.89	0.71		4.52	1.01	1.10	0.79		7.48	1.39	48.94	1,028
2009		17.74	7.76	1.96	4.85	0.67		4.53	1.03	1.11	0.85		7.75	1.46	49.71	1,044
2010		18.06	7.96	1.85	4.80	0.63		4.53	1.06	1.11	0.84		8.00	1.54	50.37	1,058
2011		17.70	8.16	1.74	4.74	0.60		4.53	1.08	1.12	0.77	0.42	8.22	1.60	50.68	1,064
2012	2.25	16.67	7.69	1.64	4.68	0.56	0.22	4.52	1.11	1.12	0.70	0.64	8.46	1.67	51.93	1,090
2013	3.64	15.70	7.24	1.54	4.62	0.53	0.36	4.52	1.13	1.13	0.64	0.83	8.70	1.72	52.29	1,098
2014	4.92	14.78	6.82	1.45	4.54	0.50	0.50	4.52	1.16	1.13	0.59	0.97	8.93	1.78	52.59	1,104
2015	6.11	13.92	6.42	1.37	4.47	0.47	0.64	4.51	1.18	1.14	0.54	1.09	9.13	1.82	52.80	1,109
2016	7.24	13.11	6.05	1.29	4.40	0.44	0.77	4.51	1.21	1.14	0.49	1.17	9.32	1.87	53.00	1,113

Year	Tbilisi				Kutaisi	Rustavi		Batumi	Gori	Poti	Zygdidi		Hypothetic		GHG emissions	
	Didi Lilo	Gldani (closed)	Iagludji (closed)	Lilo (closed)		Closed	New				Closed	New	I (MCF=0.4)	II (MCF=0.8)	$GgCH_4$	$GgCO_2eq$
2017	8.31	12.35	5.70	1.21	4.33	0.42	0.90	4.50	1.23	1.15	0.45	1.23	9.49	1.90	53.17	1,117

6.2.1. Managed Disposal Sites (5.A.1.)

All 56 landfills of Georgia are managed. 12 biggest landfills are in 7 cities with the population larger than 50,000. Methane emissions from these landfills are provided in Table 7-12. In 14 landfills waste layer is very shallow and methane is not generated. The rest 30 landfills are classified according to their MCF. Two hypothetic landfills are incorporating all these landfills. In order to calculate the methane emission the simplifying assumption was made that all the waste from landfills with shallow waste layer (<5m) are disposed on hypothetic landfill I and waste from landfills with deep waste layer (≥5m) are disposed on another hypothetic landfill II.

6.2.2. Unmanaged Waste Disposal Sites (5.A.2.)

No unmanaged landfills in Georgia.

6.2.3. Uncategorized Waste Disposal Sites (5.A.3.)

1357 illegal landfills have been identified within the frames of the project *Clean up Georgia*[121] in 2013,. According to this project the number of illegal landfills decreased to 333 in 2018.

6.3. Biological Treatment of Solid Waste (5.B.)

6.3.1. Composting (5.B.1)

NO - composting is not practiced in Georgia

6.3.2. Anaerobic Digestion at Biogas Facilities (5.B.2.)

NO - Anaerobic digesters absent in Georgia

6.4. Incineration and Open Burning of Waste (5.C.)

NO - Incineration plants absent in Georgia

NE - In Georgia, no statistics concerning “Open burning of waste”.

6.5. Wastewater Treatment and Discharge (5.D.)

The water used in households and industry contains a huge amount of toxins that significantly damage the environment. Wastewater handling systems transfer wastewater from its source to a disposal site. Wastewater treatment systems are used to biologically stabilize the wastewater prior to disposal. At the first stage of the wastewater treatment (primary treatment) larger solids from the wastewater are removed.

[121] Implemented by NGO consortium Greens Movement of Georgia/Friends of the Earth Georgia, Georgian Society of Nature Explorers “Orchis, “Ecological Awareness and Waste Management” with financial support of Swedish Government and in collaboration with the Ministry of Environment and Natural Resources Protection of Georgia and Solid Waste Management Company.

Remaining particulates are then allowed to settle. At the next stage treatment comprises the combination of biological processes that promote biodegradation by microorganisms.

Sludge is produced at both stages of treatment. Sludge is produced during the primary treatment consists of solids that are removed from the wastewater. Sludge produced during the secondary treatment is a result of biological growth in the biomass, as well as the collection of small particles. This sludge should be further treated before it can be safely disposed of. Methods of sludge treatment include aerobic and anaerobic stabilization (digestion), conditioning, centrifugation, composting, and drying.

CH_4 is produced when wastewater or sludge is anaerobically treated. The methane emissions from aerobic systems are negligible. Wastewater treatment systems generate N_2O through the nitrification and denitrification of sewage nitrogen.

6.5.1. Domestic Wastewater (5.D.1.)

Methodological issues:

CH_4 emissions directly depend on the content of the degradable organic material (DC) in the wastewater. The amount of DC in the wastewater is characterized by the BOD (Biochemical Oxygen Demand) or by COD (Chemical Oxygen Demand). The BOD concentration only reflects the amount of carbon that is aerobically biodegradable. The COD measures the total material available for chemical oxidation (both biodegradable and non-biodegradable).

The methane generation also depends on the type of the handling systems and temperature. Systems that provide anaerobic environments will generally produce CH_4 whereas systems that provide aerobic environments will normally produce little or no methane. With increases in temperature, the rate of CH_4 production increases. CH_4 production typically requires the temperature higher than 15°C.

To estimate total emissions from wastewater, the selected emissions factors are multiplied by the associated organic wastewater production and summed.

The following equation is used:

$$CH_4 Emission = \left[\sum_{i,j}\left(U_i \times T_{i,j} \times EF_j\right)\right](TOW - S) - R$$

Where:

CH_4 *Emissions*	CH_4 emissions in inventory year, kg CH_4/yr
U_i	fraction of the population in income group i in inventory year
$T_{i,j}$	degree of utilization of treatment/discharge pathway or system, *j*, for each income group fraction *i* in inventory year
i	income group: rural, urban high income and urban low income
j	each treatment/discharge pathway or system
EF_j	emission factor, kg CH_4 / kg BOD
TOW	total organics in wastewater in inventory year, kg BOD/yr
S	organic component removed as sludge in inventory year, kg BOD/yr
R	amount of CH_4 recovered in inventory year, kg CH_4/yr

The emission factor for a wastewater treatment and discharge pathway and system is a function of the maximum CH_4 producing potential (Bo) and the methane correction factor (MCF) for the wastewater treatment and discharge system.

$$EF_j = B_0 \times MCF_j$$

Where:

j	each treatment/discharge pathway or system
Bo	maximum CH_4 producing capacity, kg CH_4/kg BOD
MCF_j	methane correction factor (fraction)

(TOW) 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:

$$TOW = P \times BOD \times 0.001 \times I \times 365$$

Where:

TOW total organics in wastewater in inventory year, kg BOD/yr
P country population in inventory year, (person)
BOD country-specific per capita BOD in inventory year, g/person/day,
I correction factor for additional industrial BOD discharged into sewers (for collected the default is 1.25, for uncollected the default is 1.00.)

According to the 2006 IPCC it is a good practice to treat the three categories of residents: rural population, urban high-income population, and urban low-income population. Data on distribution of urban population by income is unavailable in Georgia. It means that summation by I index is only applicable to urban (in total) and rural population.

It is a good practice to use a default value of 0.25 $kgCH_4$/kgCOD or a default value of 0.6 $kgCH_4$/kgBOD (2006 IPCC, chapter 6, p.6.12). I = 1.0.

Emissions Factors:

When country-specific data are not available IPCC 2006 recommends selecting a BOD default value from a nearby comparable country. Greece default value BOD = 0.057 kg BOD/cap/day (20,805 kgBOD/1000 persons/yr) was used. Methane conversion factor, MCF varies within 10-80%. Calculations were carried out applying parameter MCF=50%. In villages of Georgia commonly small family latrines (3-5 persons) are used, for rural areas MCF=10%. T varies within 0.1-0.8. T=0.45 for urban and T=1 for rural areas.

Activity data:

Data on urban and rural population whose wastewater is handled are provided by the National Statistic Office of Georgia.

Table 6-13 Urban and rural population in 1990-2017 years

Year	Urban	Rural	Total, thousand habitants
1990	2,999	2,426	5,424
1991	3,005	2,449	5,453
1992	2,983	2,484	5,467
1993	2,914	2,432	5,346
1994	2,653	2,277	4,930

Year	Urban	Rural	Total, thousand habitants
2004	2,252	1,935	4,186
2005	2,238	1,863	4,102
2006	2,225	1,792	4,017
2007	2,212	1,720	3,932
2008	2,199	1,649	3,848

Year	Urban	Rural	Total, thousand habitants	Year	Urban	Rural	Total, thousand habitants
1995	2,568	2,226	4,794	2009	2,188	1,641	3,829
1996	2,483	2,191	4,675	2010	2,172	1,628	3,800
1997	2,413	2,146	4,558	2011	2,157	1,617	3,774
1998	2,366	2,139	4,505	2012	2,137	1,602	3,739
1999	2,338	2,132	4,470	2013	2,125	1,593	3,718
2000	2,308	2,127	4,435	2014	2,124	1,593	3,717
2001	2,293	2,102	4,395	2015	2,127	1,595	3,722
2002	2,278	2,078	4,356	2016	2,131	1,598	3,729
2003	2,265	2,006	4,271	2017	2,130	1,597	3,726

Table 6-14 CH_4 emissions from domestic & commercial wastewater handling

Year	CH4 from urban population	CH4 from rural population	Emission in $GgCH_4$	Emission in $GgCO_2eq$	Year	CH_4 from urban population	CH_4 from rural population	Emission in $GgCH_4$	Emission in $GgCO_2eq$
1990	8.42	3.03	11.45	240	2004	6.32	2.42	8.74	184
1991	8.44	3.06	11.50	241	2005	6.29	2.33	8.61	181
1992	8.38	3.10	11.48	241	2006	6.25	2.24	8.49	178
1993	8.18	3.04	11.22	236	2007	6.21	2.15	8.36	176
1994	7.45	2.84	10.29	216	2008	6.18	2.06	8.23	173
1995	7.21	2.78	9.99	210	2009	6.15	2.05	8.19	172
1996	6.97	2.74	9.71	204	2010	6.10	2.03	8.13	171
1997	6.78	2.68	9.46	199	2011	6.06	2.02	8.08	170
1998	6.65	2.67	9.32	196	2012	6.00	2.00	8.00	168
1999	6.57	2.66	9.23	194	2013	5.97	1.99	7.96	167
2000	6.48	2.66	9.14	192	2014	5.97	1.99	7.95	167
2001	6.44	2.62	9.06	190	2015	5.97	1.99	7.97	167
2002	6.40	2.59	8.99	189	2016	5.99	1.99	7.98	168
2003	6.36	2.50	8.87	186	2017	5.98	1.99	7.97	167

6.5.2. Nitrous Oxide from Human Sewage

Consumption of foodstuffs by humans results in the production of sewage. Main source of nitrogen from human sewage is protein, a complex, high-molecular-mass, organic compound that consists of amino acids joined by peptide bonds.

Sewage nitrogen production can be estimated based on FAO per capita protein consumption data and human population counts. FAO Statistics Division provides per person protein consumption data for Georgia for years 1990-1992 (56 g/person/day), 1995-1997 (69 g/person/day), 2000-2002 (72 g/person/day) and 2005-2007 (77 g/person/day). Protein consumption for years 2008-2017 was estimated assuming that by 2017 it had increased by 1 g/person/day annually.

The emissions of N_2O from human sewage are calculated by the formula:

$$N_2O(S) = Protein \times \text{fracNPR} \times NR_{people} \times EF_6$$

Where:

$N_2O(s)$	N_2O emissions from human sewage (kg N_2O-N/yr)
Protein	annual per capita protein intake (kg/person/yr)
NR_{PEOPLE}	number of people in the country
EF_6	emissions factor [default 0.01 (0,002-0,12) kg N_2O-N/kg sewage-N produced
FracNPR	fraction of nitrogen in protein, default value =0.16 kg N/kg protein

Table 6-15 N_2O emissions (in Gg) from humane sewage in 1990-2017 years

Year	Population	Protein consumption	N_2O emission in Gg	in CO_2eq	Year	Population	Protein consumption	N_2O emission in Gg	in CO_2eq
1990	5,424	56	0.18	**55**	2004	4,186	76	0.19	**58**
1991	5,453	56	0.18	**55**	2005	4,102	77	0.18	**57**
1992	5,467	56	0.18	**55**	2006	4,017	77	0.18	**56**
1993	5,346	60	0.19	**58**	2007	3,932	77	0.18	**55**
1994	4,930	65	0.19	**58**	2008	3,848	78	0.18	**54**
1995	4,794	69	0.19	**60**	2009	3,829	79	0.18	**55**
1996	4,675	69	0.19	**58**	2010	3,800	80	0.18	**55**
1997	4,558	69	0.18	**57**	2011	3,774	81	0.18	**55**
1998	4,505	70	0.18	**57**	2012	3,739	82	0.18	**56**
1999	4,470	71	0.19	**57**	2013	3,718	83	0.18	**56**
2000	4,435	72	0.19	**58**	2014	3,717	84	0.18	**57**
2001	4,395	72	0.18	**57**	2015	3,722	85	0.18	**57**
2002	4,356	72	0.18	**57**	2016	3,729	86	0.19	**58**
2003	4,271	74	0.18	**57**	2017	3,726	87	0.19	**59**

6.5.3. Industrial Wastewater (5.D.2.)

Assessment of CH_4 production potential from industrial wastewater streams is based on the concentration of degradable organic matter in the wastewater, the volume of wastewater and the wastewater treatment system.

Methodology:

The method for calculating emissions from industrial wastewater is similar to the method used for domestic wastewater, but the development of emission factors and activity data is more complex since there are many types of wastewater, and many different industries to track. The most accurate estimates of emissions for this source category are based on measured data from point sources. Due to the high costs of measurements and the potentially large number of point sources, comprehensive measurement data are absent in Georgia.

COD is the appropriate DC indicator for industrial wastewater streams.2006 IPCC provides default COD values for various industries by region. Default values of the wastewater produced per unit product by industry in m3/tonne of product are also provided in IPCC GPG.

The equation to estimate CH4 emissions from industrial wastewater is as follows:

$$CH_4 Emissions = \sum_i [(TOW_i - S_i) \times EF_i - R_i]$$

Where:

- TOW_i total organically degradable material in wastewater from industry I in inventory year, kg COD/year
- I industrial sector
- S_i organic component removed as sludge in inventory year, kg COD/year
- EF_i emission factor for industry i, kg CH_4/kg CODr
- R_i amount of CH4 recovered in inventory year, kg CH_4/year

Emission Factor:

Emission factor depends on the maximum CH4 producing capacity (Bo) in each industry, and on methane correction factor (MCF).

$$EF_j = B_0 \times MCF_j$$

Where:

EF_j	emission factor for each treatment/discharge pathway or system, kg CH_4/kg COD
j	each treatment/discharge pathway or system
B_o	maximum CH_4 producing capacity, kg CH/kg COD
MCF_j	methane correction factor (fraction)

If no country-specific data are available, it is a good practice to use the IPCC COD-default factor for Bo (0.25 kg CH_4/kg COD). MCF=0.3. Organic components are not removed and CH_4 is not recovered, i.e. S=0 and R=0.

The total organic wastewater (TOWI) for the industry is calculated by the formulae:

$$TOW = P_i \times W_i \times COD_i$$

Where:

$TOWi$ = total organically degradable material in wastewater for industry i, kg COD/yr

i	industrial sector
P_i	total industrial product for industrial sector i, t/yr
W_i	wastewater generated, m3/t product
COD_i	chemical oxygen demand (industrial degradable organic component in wastewater), kg COD/m^3

Activity data:

Specified production data for different industries provided by The National Statistics Office of Georgia.

GHG emissions from industrial wastewater handling are presented in *Table 6-16*.

Table 6-16 CH_4 emissions from industrial wastewater handling in 1990-2017 years

Year	Alcohol Refining	Beer & Malt	Dairy Products	Meat & Poultry	Organic Chemicals	Pulp & Paper (combined)	Veget, Fruits & Juices	Wine & Vinegar	Soft drinks	Canneries	Total in Gg CH_4	Total in Gg CO_2eq
1990	0.16	0.06	0.18	0.30	6.60	1.45	0.004	0.04	0.04	0.000	8.84	186
1991	0.15	0.04	0.11	0.03	5.42	0.03	0.002	0.03	0.02	0.000	5.83	122
1992	0.13	0.02	0.02	0.01	4.24	0.01	0.000	0.05	0.01	0.000	4.47	94
1993	0.23	0.01	0.01	0.001	3.06	-	0.000	0.03	0.002	0.000	3.34	70
1994	0.05	0.004	0.01	0.000	1.88	-	0.000	0.02	0.001	0.000	1.96	41
1995	0.02	0.004	0.003	0.000	2.48	0.002	0.000	0.01	0.002	0.000	2.52	53
1996	0.03	0.003	0.003	0.001	3.07	0.002	0.000	0.01	0.005	0.000	3.12	66
1997	0.05	0.01	0.004	0.002	3.67	0.003	0.000	0.01	0.01	0.000	3.76	79
1998	0.02	0.01	0.005	0.002	4.27	0.002	0.000	0.01	0.01	0.000	4.32	91
1999	0.09	0.01	0.003	0.003	4.87	0.003	0.000	0.01	0.01	0.000	4.99	105
2000	0.09	0.02	0.003	0.004	5.46	0.004	0.000	0.004	0.01	0.000	5.59	117
2001	0.10	0.02	0.003	0.001	5.63	0.001	0.000	0.01	0.01	0.000	5.78	121
2002	0.03	0.02	0.01	0.001	5.80	-	0.000	0.01	0.01	0.000	5.87	123
2003	0.02	0.02	0.004	0.002	5.97	-	0.000	0.01	0.02	0.000	6.05	127
2004	0.09	0.03	0.005	0.005	6.14		0.000	0.01	0.03	0.000	6.30	132
2005	0.11	0.04	0.01	0.01	6.31	0.003	0.000	0.01	0.04	0.000	6.53	137
2006	0.15	0.05	0.01	0.01	6.74	-	0.02	0.01	0.05	0.004	7.04	148

Year	Alcohol Refining	Beer & Malt	Dairy Products	Meat & Poultry	Organic Chemicals	Pulp & Paper (combined)	Veget, Fruits & Juices	Wine & Vinegar	Soft drinks	Canneries	Total in Gg CH_4	Total in Gg CO_2eq
2007	0.13	0.05	0.01	0.01	7.17	-	0.07	0.004	0.05	0.01	7.50	158
2008	0.16	0.04	0.01	0.02	7.60	-	0.02	0.005	0.04	0.01	7.91	166
2009	0.12	0.05	0.28	0.01	8.03	0.24	0.03	0.004	0.04	0.01	8.80	185
2010	0.11	0.06	0.30	0.02	8.46	0.43	0.03	0.01	0.04	0.01	9.46	199
2011	0.13	0.05	0.36	0.03	9.21	0.53	0.07	0.01	0.04	0.02	10.45	220
2012	0.13	0.07	0.37	0.04	9.18	0.73	0.06	0.01	0.05	0.02	10.66	224
2013	0.08	0.07	0.34	0.05	9.26	0.57	0.05	0.02	0.05	0.02	10.51	221
2014	0.08	0.07	0.35	0.06	9.25	0.59	0.09	0.03	0.06	0.02	10.60	223
2015	0.05	0.06	0.34	0.06	9.80	0.45	0.04	0.02	0.06	0.03	10.91	229
2016	0.02	0.07	0.32	0.07	9.34	0.48	0.06	0.02	0.06	0.04	10.47	220
2017	0.03	0.06	0.35	0.07	8.95	0.76	0.08	0.02	0.07	0.03	10.42	219

Chapter 7. Other (CRF Sector 6)

Indirect N_2O emissions from the atmospheric deposition of nitrogen in NO_x and NH_3 is not estimated due to the lack of data.

Emissions from the other (5B) category has not occurred during this period.

Chapter 8. Recalculation of GHG emissions

During this inventory GHG emissions and removals were calculated using 2006 IPCC guidelines for the years 1991-1993, 1995-1999, 2001-2004, 2006-2009, 2016 and 2017, and figures were recalculated for all the previous years (1990, 1994, 2000, 2005, 2010-2015) in all sectors except for the IPPU sector where GHG emissions had been recalculated for all previous years during the last inventory.

Table 8-1 Difference in total GHG emissions in the latest and the previous national inventories

National GHG emissions, CO2 eq.	Emissions in Gg									
	1990	**1994**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Total (excluding LULUCF)-2017	45,813	15,745	10,923	11,168	13,688	16,027	16,927	15,964	16,861	18,214
Total (excluding LULUCF)-2015	45,607	15,415	10,479	10,684	13,208	15,563	16,549	15,487	16,278	17,589
Difference-%	**0%**	**2%**	**4%**	**5%**	**4%**	**3%**	**2%**	**3%**	**4%**	**4%**
Total (including LULUCF)-2017	39,461	9,121	5,892	7,006	9,151	11,163	12,178	11,130	12,252	13,597
Total (including LULUCF)-2015	38,768	8,685	5,472	5,926	9,595	10,490	12,738	10,750	13,780	13,707
Difference-%	**2%**	**5%**	**8%**	**18%**	**-5%**	**6%**	**-4%**	**4%**	**-11%**	**-1%**

More specific information on differences in results by sectors are provided below.

Energy

Table 8-2 Category-specific documentation of recalculations (Transport-1A3)

Transport Sector/CO2 eq.	Emissions in Gg									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	3,822	1,419	945	1,537	2,580	2,563	2,672	3,301	3,735	4,139
Previous Data	3,822	1,420	945	1,537	2,601	2,585	2,690	3,380	3,758	4,162
Difference %	0.0%	0.0%	0.0%	0.0%	-0.8%	-0.9%	-0.7%	-2.3%	-0.6%	-0.6%
Documentation Reason for Recalculation: British Petroleum Georgia provided specified data of natural gas and diesel consumption which is used in the oil and gas transit pipeline substations. Also, The Ministry of Economy and Sustainable Development provided data on oil products consumption by international Bunkers (Navigation). Those data were previously unknown and aggregated in the transport sector and in recent inventory it was extracted.										

Agriculture

Table 8-3 Category-Specific Documentation of Recalculations (Enteric fermentation)

Enteric fermentation / CH_4	Emissions in Gg									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	89.7	63.5	78.3	80.9	72.3	71.6	76.2	81.5	87.7	91.1
Previous Data	77.1	51.8	62.9	64.7	56.4	56.4	59.8	63.6	68.1	70.1
Difference %	16%	23%	24%	25%	28%	27%	27%	28%	29%	30%
Documentation Reason for Recalculation: The specified data on cattle distribution by breeds has been provided by the highly experienced person Mr. Levan Tortladze - Head of the Department of Zootechny of the Agrarian University of Georgia. Emission factor for enteric fermentation significantly depends on cattle breed.										

Table 8-4 Category-Specific Documentation of Recalculations (Manure management)

Manure management / CH_4	Emissions in Gg									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	5.8	3	3.5	3.6	2	2	2.4	2.5	2.5	2.6
Previous Data	9	5.2	6.2	6.4	4.4	4.4	5	5.2	5.5	5.6
Difference %	-36%	-42%	-44%	-44%	-55%	-55%	-52%	-52%	-55%	-54%
Documentation Reason for Recalculation: In case of enteric fermentation, specified data on cattle distribution by breeds was used. More significantly, recalculations were performed applying Tier 2 approach.										

Table 8-5 Category-Specific Documentation of Recalculations (Manure management)

Manure management / N_2O	Emissions in Gg									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	1.17	0.81	1	1.03	0.9	0.89	0.96	1.02	1.1	1.15
Previous Data	1.21	0.8	0.98	1	0.85	0.85	0.91	0.96	1.04	1.07
Difference %	-3%	1%	2%	3%	6%	5%	5%	6%	6%	7%
Documentation Reason for Recalculation: In case of enteric fermentation, specified data on cattle distribution by breeds was used. Nitrogen excretion rate depends on amount of managed manure N available for soil application, i.e. on cattle breed.										

Table 8-6 Category-Specific Documentation of Recalculations (Direct emissions from managed soils)

Direct emissions from managed soils / N_2O	Emissions in Gg									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	3.49	2.08	2.59	2.74	2.44	2.33	2.56	3	2.82	2.87
Previous Data	3.54	2.07	2.56	2.7	2.35	2.24	2.45	2.9	2.7	2.74
Difference %	-1%	0%	1%	1%	4%	4%	4%	3%	4%	5%

Documentation Reason for Recalculation:
In case of enteric fermentation, specified data on cattle distribution by breeds was used. Amount of animal manure applied to soils and amount of urine and dung deposited by grazing animals on pasture, range and paddock depends on cattle breed.

Table 8-7 Category-Specific Documentation of Recalculations (Indirect emissions from managed soils)

Indirect emissions from managed Soils / N_2O	Emissions in Gg CO_2eq									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	637	377	477	502	453	429	473	560	517	525
Previous Data	645	375	472	494	438	414	455	542	498	503
Difference %	-1%	1%	1%	2%	3%	4%	4%	3%	4%	4%

Documentation Reason for Recalculation:
In case of enteric fermentation, specified data on cattle distribution by breeds was used. Atmospheric deposition of N volatilized from managed soils and Nitrogen leaching/runoff from managed soils depends on amount of animal manure applied to soils and amount of urine and dung deposited by grazing animals on pasture, range and paddock, i.e. on cattle breed.

Land-use, Land Use Change and Forestry

Table 8-8 Category-Specific Documentation of Recalculations (Forest lands)

Forest lands/CO2	Emissions in Gg									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	(6,224)	(6,204)	(6,091)	(5,497)	(5,375)	(5,736)	(5,616)	(5,794)	(5,498)	(5,484)
Previous Data	(6,458)	(6,374)	(6,174)	(5,896)	(5,790)	(6,078)	(5,831)	(5,774)	(5,646)	(5,621)
Difference %	-3.6%	-2.7%	-1.3%	-6.8%	-7.2%	-5.6%	-3.7%	0.3%	-2.6%	-2.4%

Documentation Reason for Recalculation:
Activity data and the emissions factors has been updated and specified.

Table 8-9 Category-Specific Documentation of Recalculations (Perennial crops)

Perennial crops/CO2	Emissions in Gg									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	(2,746)	(2,549)	(1,358)	(924)	(862)	(839)	(839)	(847)	(847)	(847)
Previous Data	(2,695)	(2,417)	(1,586)	(1,163)	(924)	(655)	(963)	(1,001)	(693)	(847)
Difference %	1.9%	5.5%	-14.4%	-20.6%	-6.7%	28.1%	-12.9%	-15.4%	22.2%	0.0%

Documentation Reason for Recalculation:
Activity data and the emissions factors has been updated and specified.

Table 8-10 Category-Specific Documentation of Recalculations (Arable lands)

Arable lands/CO2	Emissions in Gg									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	(283)	(788)	(494)	(653)	(1,211)	(1,200)	(1,206)	(1,105)	(1,175)	(1,198)
Previous Data	(570)	(775)	(480)	(640)	(1,198)	(1,187)	(1,192)	(1,091)	(1,080)	(1,096)
Difference %	-50.4%	1.7%	2.9%	2.0%	1.1%	1.1%	1.2%	1.3%	8.8%	9.3%
Documentation Reason for Recalculation: Activity data and the emissions factors has been updated and specified.										

Table 8-11 Category-Specific Documentation of Recalculations (Grasslands)

Grassland/CO2	Emissions in Gg									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	2,901	2,915	2,912	2,912	2,912	2,912	2,912	2,912	2,912	2,912
Previous Data	2,800	2,813	2,810	2,811	2,811	2,811	2,811	2,811	2,811	2,811
Difference %	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%
Documentation Reason for Recalculation: Activity data and the emissions factors has been updated and specified.										

Waste

Table 8-12 Category-Specific Documentation of Recalculations (Emissions from Solid Waste Disposal Sites)

Emissions from Solid Waste Disposal Sites / CH4	Emissions in Gg									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	31.2	36.9	42.9	46.6	48.5	49.3	49.7	50.1	50.5	50.7
Previous Data	26.6	31.6	36.4	39.2	42	42.4	42.5	42.6	42.6	42.6
Difference %	17%	17%	18%	19%	15%	16%	17%	18%	19%	19%
Documentation Reason for Recalculation: Compared to previous inventory, time Delay - the period between deposition of the waste and full production of CH4 is considered. Specified data on amount of solid waste disposal on landfills was used.										

Table 8-13 Category-Specific Documentation of Recalculations (CH4 Emissions from Domestic Wastewater Handling)

Domestic Wastewater Handling / CH_4	Emissions in Gg									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	11.5	10.3	9.1	8.6	8.1	8.1	8	8	8	8
Previous Data	10.8	10.4	9.1	8.7	8.7	8.7	8.6	8.6	8.7	8.7
Difference %	6%	-1%	0%	-1%	-7%	-7%	-7%	-7%	-8%	-8%
Documentation Reason for Recalculation: Data on rural and urban population was specified.										

Table 8-14 Category-Specific Documentation of Recalculations (N2O Emissions from Domestic Wastewater Handling)

Domestic Wastewater Handling / N_2O	Emissions in Gg									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Latest Data	11.5	10.3	9.1	8.6	8.1	8.1	8	8	8	8
Previous Data	10.8	10.4	9.1	8.7	8.7	8.7	8.6	8.6	8.7	8.7
Difference %	6%	-1%	0%	-1%	-7%	-7%	-7%	-7%	-8%	-8%
Documentation Reason for Recalculation: Corrected data on per capita protein consumption was used										

ANNEX A. THE NATIONAL ENERGY BALANCE FOR THE 2016 AND 2017 YEAR

Georgia 2016 (TJ)	Anthracite	Other Bit. Coal	Lignite/Brown Coal	Coke Oven Coke	Charcoal	Fuel wood	Other vegetal materials and residual	Natural Gas	Crude Oil	Liquefied Petroleum Gases	Motor Gasoline	Kerosene type Jet Fuel	Kerosene	Road diesel	Heating and other gas oil	Fuel oil-low sulphur (< 1%)	Lubricants	Bitumen	Non-specified Petroleum Prods.
Production	-	-	5,041	-	9	16,007	225	231	1,639	-	-	-	-	-	-	-	-	-	-
Imports	202	2,415	-	4,308	8	-	-	82,281	1,813	578	25,351	3,056	1	27,608	434	1,776	834	3,937	342
Exports	-	-	26	-	-	55	-	-	770	-	-	-	-	16	-	764	76	-	3,675
International Marine Bunkers														23.6					
International Aviation Bunkers	-	-	-	-	-	-	-	-	-	-	-	3,048	-	-	-	-	-	-	-
Stock Changes	(118)	(125)	(151)	(606)	(3)	-	-	-	15	162	625	39	-	(699)	-	936	38	43	(132)
Domestic Supply	**84**	**2,290**	**4,863**	**3,701**	**14**	**15,953**	**225**	**82,512**	**2,697**	**740**	**25,976**	**47**	**1**	**26,870**	**434**	**1,948**	**796**	**3,980**	**(3,464)**
Statistical Differences	-	-	-	-	-	(0)	-	0	0	(0)	(1)	0	0	0	(0)	0	-	-	1
Transformation Sector - Input	-	-	450	-	-	-	-	18,256	2,697	-	-	-	-	-	-	2,210	-	-	-
MA Thermal Electricity Plants	-	-	450	-	-	-	-	18,256	-	-	-	-	-	-	-	-	-	-	-
Petroleum Refineries	-	-	-	-	-	-	-	-	2,697	-	-	-	-	-	-	2,210	-	-	-
Transformation Sector - Production	-	-	-	-	-	-	-	-	-	-	311	-	-	400	-	327	-	-	3,804
MA Thermal Electricity Plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum Refineries	-	-	-	-	-	-	-	-	-	-	311	-	-	400	-	327	-	-	3,804
Energy Sector	-	-	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coal Mines	-	-	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oil and Gas Extraction	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum Refineries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transmission Losses								**819**											
Distribution Losses	-	-	-	-	-	-	-	**3,948**	-	-	-	-	-	-	-	-	-	-	-
Final Consumption	**84**	**2,290**	**4,394**	**3,701**	**14**	**15,953**	**225**	**59,488**	**-**	**740**	**26,288**	**47**	**1**	**27,269**	**435**	**64**	**796**	**3,980**	**338**
Industry Sector	56	2,290	4,349	3,701	-	63	-	4,039	-	1	-	-	-	-	-	20	-	-	287
Iron and steel	-	-	-	3,701	-	-	-	459	-	-	-	-	-	-	-	2	-	-	-
Chemical (including petrochemical)	-	-	-	-	-	-	-	144	-	-	-	-	-	-	-	-	-	-	-
Non-ferrous metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-metallic minerals	-	2,290	4,342	-	-	-	-	1,344	-	-	-	-	-	-	-	12	-	-	287
Transport equipment	-	-	-	-	-	-	-	14	-	-	-	-	-	-	-	-	-	-	-
Machinery	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
Mining and quarrying	-	-	-	-	-	-	-	70	-	-	-	-	-	-	-	-	-	-	-
Food, beverages and tobacco	56	-	-	-	-	63	-	1,337	-	-	-	-	-	-	-	-	-	-	-
Paper, pulp and printing	-	-	-	-	-	-	-	74	-	-	-	-	-	-	-	-	-	-	-
Wood and wood products	-	-	8	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-	508	-	-	-	-	-	-	-	6	-	-	-
Textiles and leather	-	-	-	-	-	-	-	35	-	-	-	-	-	-	-	-	-	-	-
Not elsewhere specified (Industry)	-	-	-	-	-	-	-	42	-	1	-	-	-	-	-	-	-	-	-
Transport Sector	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**13,005**	**-**	**32**	**26,251**	**47**	**-**	**26,677**	**-**	**18**	**-**	**-**	**-**
Road	-	-	-	-	-	-	-	9,660	-	32	26,251	-	-	25,758	-	-	-	-	-
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	430	-	18	-	-	-
Domestic aviation	-	-	-	-	-	-	-	-	-	-	-	47	-	-	-	-	-	-	-
Domestic navigation	-	-	-	-	-	-	-	-	-	-	-	-	-	29	-	-	-	-	-
Pipeline transport	-	-	-	-	-	-	-	3,345	-	-	-	-	-	460		-	-	-	-
Not elsewhere specified (Transport)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Sectors	**28**	**-**	**45**	**-**	**14**	**15,889**	**225**	**34,661**	**-**	**707**	**37**	**-**	**1**	**592**	**435**	**26**	**-**	**-**	**-**
Commercial and public services	16	-	11	-	14	167	14	6,678	-	-	-	-	-	-	430	26	-	-	-
Residential	7	-	28	-	-	15,722	211	27,615	-	707	-	-	1	-	-	-	-	-	-
Agriculture/forestry	4	-	6	-	-	0	-	368	-	-	37	-	-	592	4	-	-	-	-
Fishing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Not elsewhere specified (Other)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-Energy Use	-	-	-	-	-	-	-	7,784	-	-	-	-	-	-	-	-	796	3,980	51

Georgia 2017 (TJ)	Anthracite	Other Bit. Coal	Lignite/Brown Coal	Coke Oven Coke	Charcoal	Fuel wood	Other vegetal materials and residual	Natural Gas	Crude Oil	Liquefied Petroleum Gases	Motor Gasoline	Kerosene type Jet Fuel	Kerosene	Road diesel	Heating and other gas oil	Fuel oil-low sulphur (< 1%)	Lubricants	Bitumen	Non-specified Petroleum Prods.
Production	-	-	4,558	-	3	15,115	162	298	1,360	-	-	-	-	-	-	-	-	-	-
Imports	434	3,685	-	3,954	-	-	-	85,120	2,531	699	23,487	4,326	-	23,494	997	3,503	866	3,952	53
Exports	-	-	37	375	-	66	-	-	3,029	-	62	-	-	473	-	3,740	167	-	
International Marine Bunkers														63.22					
International Aviation Bunkers	-	-	-	-	-	-	-	-	-	-	-	4,087	-	-	-	-	-	-	-
Stock Changes	(241)	(245)	(32)	519	-	-	-	-	200	60	88	(213)	-	588	-	(52)	(0)	38	(49)
Domestic Supply	**193**	**3,440**	**4,488**	**4,098**	**3**	**15,049**	**162**	**85,418**	**1,062**	**759**	**23,514**	**26**	**-**	**23,546**	**997**	**(289)**	**699**	**3,990**	**4**
Statistical Differences	-	-	-	-	-	0	0	-	(0)	-	-	0	-	0	-	(0)	-	-	0
Transformation Sector - Input	**-**	**-**	**634**	**-**	**-**	**-**	**-**	**18,235**	**1,063**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
MA Thermal Electricity Plants	-	-	634	-	-	-	-	18,235	-	-	-	-	-	-	-	-	-	-	-
Petroleum Refineries	-	-	-	-	-	-	-	-	1,063	-	-	-	-	-	-	-	-	-	-
Transformation Sector - Production	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**97**	**-**	**-**	**425**	**-**	**352**	**-**	**-**	**129**
MA Thermal Electricity Plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum Refineries	-	-	-	-	-	-	-	-	-	-	97	-	-	425	-	352	-	-	129
Energy Sector	**-**	**-**	**15**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Coal Mines	-	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oil and Gas Extraction	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum Refineries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transmission Losses								1,199											
Distribution Losses	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2,144**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Final Consumption	**193**	**3,440**	**3,839**	**4,098**	**3**	**15,048**	**162**	**63,840**	**-**	**759**	**23,610**	**26**	**-**	**23,971**	**997**	**63**	**699**	**3,990**	**133**
Industry Sector	**167**	**3,440**	**3,808**	**4,098**	**-**	**46**	**0**	**4,851**	**-**	**-**	**-**	**-**	**-**	**-**	**59**	**40**	**-**	**-**	**57**
Iron and steel	-	38	-	4,098	-	-	-	571	-	-	-	-	-	-	8	-	-	-	-
Chemical (including petrochemical)	-	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-
Non-ferrous metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-metallic minerals	-	3,402	3,808	-	-	1	-	1,362	-	-	-	-	-	-	-	20	-	-	49
Transport equipment	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
Machinery	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
Mining and quarrying	-	-	-	-	-	-	-	32	-	-	-	-	-	-	-	-	-	-	-
Food, beverages and tobacco	167	-	-	-	-	44	0	1,726	-	-	-	-	-	-	-	20	-	-	-
Paper, pulp and printing	-	-	-	-	-	-	-	63	-	-	-	-	-	-	-	-	-	-	-
Wood and wood products	-	-	-	-	-	1	-	25	-	-	-	-	-	-	-	-	-	-	-
Construction	-	-	-	-	-	1	-	742	-	-	-	-	-	-	51	-	-	-	-
Textiles and leather	-	-	-	-	-	-	-	49	-	-	-	-	-	-	-	-	-	-	-
Not elsewhere specified (Industry)	-	-	-	-	-	-	-	77	-	-	-	-	-	-	-	-	-	-	8
Transport Sector	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**12,166**	**-**	**129**	**23,553**	**26**	**-**	**23,464**	**520**	**18**	**-**	**-**	**-**
Road	-	-	-	-	-	-	-	8,785	-	129	23,553	-	-	23,121	-	-	-	-	-
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	439	18	-	-	-
Domestic aviation	-	-	-	-	-	-	-	-	-	-	-	26	-	-	-	-	-	-	-
Domestic navigation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	81	-	-	-	-
Pipeline transport	-	-	-	-	-	-	-	3,381	-	-	-	-	-	342		-	-	-	-
Not elsewhere specified (Transport)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Sectors	**26**	**-**	**31**	**-**	**3**	**15,002**	**162**	**38,231**	**-**	**630**	**57**	**-**	**-**	**507**	**418**	**4**	**-**	**-**	**-**
Commercial and public services	15	-	9	-	3	144	12	6,853	-	-	-	-	-	-	405	4	-	-	-
Residential	6	-	17	-	-	14,857	150	30,940	-	630	-	-	-	-	-	-	-	-	-
Agriculture/forestry	5	-	5	-	-	1	-	438	-	-	57	-	-	507	13	-	-	-	-
Fishing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Not elsewhere specified (Other)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-Energy Use	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**8,593**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**699**	**3,990**	**76**

ANNEX B. UNCERTAINTY ANALYSIS

Results of the Uncertainty Analysis

	A	B	C	D	E	F	G	H	I	J	K	L	M
	2006 IPCC Categories	Gas	Emissions of 1990	Emissions of 2017	Uncertainty of activity data	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2017	A type sensitivity	B type sensitivity	Uncertainty in trend in national emissions introduced by emission factor /estimation parameter 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 (Note A)	Input data (Note A)	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I * F Note C	J* E * $\sqrt{2}$ Note D	$K^2 + L^2$
			Gg CO2-eq.	**Gg CO2-eq.**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
1A1	Electricity and Heat Production - Liquid Fuels	**CO_2**	8172.17	0.00	1	6.1	6.18	0.00	-0.08	0.00	0.00	-0.08	0.01
1A1	Electricity and Heat Production - Gaseous fuels	**CO_2**	4604.23	1022.98	1	3.9	4.03	0.07	-0.02	0.03	0.14	-0.02	0.02
1A1	Heat Production and other Energy Industries - Solid Fuels	**CO_2**	955.46	506.90	1	12.4	12.44	0.17	0.00	0.01	0.22	0.00	0.05
1A2	Manufacturing Industries and Construction - solid fuels	**CO_2**	3519.07	722.80	5	12.4	13.37	0.41	-0.02	0.02	0.32	-0.08	0.10
1A2	Manufacturing Industries and Construction - biomass	**CO_2**	0.00	5.20	5	18.7	19.36	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Manufacturing Industries and Construction - liquid fuels	**CO_2**	2008.10	14.70	5	6.1	7.89	0.00	-0.02	0.00	0.00	-0.09	0.01
1A2	Manufacturing Industries and Construction - Gaseous Fuels	**CO_2**	2007.79	272.20	5	3.9	6.34	0.01	-0.01	0.01	0.04	-0.06	0.01
1A3a	Civil aviation	**CO_2**	0.00	1.80	5	4.2	6.53	0.00	0.00	0.00	0.00	0.00	0.00
1A3a i	International Aviation (International Bunkers) - Liquid Fuels	**CO_2**	608.63	292.23	5	4.2	6.53	0.02	0.00	0.01	0.04	0.01	0.00
1A3b	Road Transportation - Liquid Fuels	**CO_2**	3603.22	3353.65	5	3.1	5.88	1.69	0.05	0.08	0.37	0.25	0.19

1A3b	Road transportation - Gaseous Fuels	CO_2	0.00	492.84	5	3.9	6.34	0.04	0.01	0.01	0.07	0.06	0.01
1A3c	Other transportation	CO_2	141.32	195.70	5	5	7.07	0.01	0.00	0.00	0.03	0.02	0.00
1A3d	International water-borne navigation (International bunkers) - Liquid Fuels	CO_2	0.00	4.68	5	4.2	6.53	0.00	0.00	0.00	0.00	0.00	0.00
1A4a	Commercial/Institutional- solid fuels	CO_2	85.85	2.30	5	12.4	13.37	0.00	0.00	0.00	0.00	0.00	0.00
1A4a	Commercial/Institutional- liquid fuels	CO_2	762.45	30.33	5	6.1	7.89	0.00	-0.01	0.00	0.01	-0.03	0.00
1A4a	Commercial/Institutional- Gaseous Fuels	CO_2	228.21	384.45	5	3.9	6.34	0.03	0.01	0.01	0.05	0.04	0.00
1A4a	Commercial/Institutional- biomass	CO_2	122.19	17.71	5	18.7	19.36	0.00	0.00	0.00	0.01	0.00	0.00
1A4b	Residential - solid fuels	CO_2	73.83	2.29	5	12.4	13.37	0.00	0.00	0.00	0.00	0.00	0.00
1A4b	Residential - liquid fuels	CO_2	986.76	39.77	5	6.1	7.89	0.00	-0.01	0.00	0.01	-0.04	0.00
1A4b	Residential - Gaseous Fuels	CO_2	2627.65	1735.73	5	3.9	6.34	0.53	0.02	0.04	0.24	0.09	0.07
1A4b	Residential - biomass	CO_2	1605.97	1679.00	5	18.7	19.36	4.58	0.03	0.04	1.10	0.13	1.24
1A4c	Stationary - solid fuels	CO_2	56.76	1.05	5	12.4	13.37	0.00	0.00	0.00	0.00	0.00	0.00
1A4c	Stationary - Liquid Fuels	CO_2	390.99	42.50	5	6.1	7.89	0.00	0.00	0.00	0.01	-0.01	0.00
1A4c	Stationary - Gaseous Fuels	CO_2	70.48	248.94	5	3.9	6.34	0.01	0.01	0.01	0.03	0.03	0.00
1A4c	Stationary - biomass	CO_2	421.12	0.12	5	18.7	19.36	0.00	0.00	0.00	0.00	-0.02	0.00
1B1	Fugitive Emissions from Solid Fuel Mining and transformation	CO_2	62.20	10.10	5	300	300.04	0.04	0.00	0.00	0.11	0.00	0.01
1B2	Fugitive Emissions from Fuels - Oil and Natural Gas (Flaring, production, distribution)	CO_2	11.68	2.09	5	300	300.04	0.00	0.00	0.00	0.02	0.00	0.00
2A1	Cement Production	CO_2	504.97	658.74	5	5	7.07	0.09	0.01	0.02	0.12	0.06	0.02
2A2	Lime Production	CO_2	36.66	53.39	20	15	25.00	0.01	0.00	0.00	0.03	0.02	0.00
2A3	Glass production	CO_2	30.30	15.12	5	10	11.18	0.00	0.00	0.00	0.01	0.00	0.00
2B1	Ammonia Production	CO_2	524.78	404.32	5	6	7.81	0.04	0.01	0.01	0.09	0.03	0.01
2C1	Cast Iron and Steel Production	CO_2	2492.08	43.25	10	25	26.93	0.01	-0.02	0.00	0.04	-0.22	0.05
2C2	Ferroalloys Production	CO_2	142.87	420.50	5	25	25.50	0.50	0.01	0.01	0.37	0.05	0.14
2D1	Lubricant Use	CO_2	0	10.25	5	50	50.25	0.00	0.00	0.00	0.02	0.00	0.00

5A	Forest land	CO_2	-6224.20	-5578.10	5	20	20.62	57.38	-0.08	-0.14	-3.92	-0.40	15.55
5B	Cropland	CO_2	-3029.90	-2257.80	10	75	75.66	126.64	-0.03	-0.06	-5.95	-0.28	35.53
5C	Grassland	CO_2	901.00	2912.10	10	75	75.66	210.68	0.06	0.07	7.68	0.64	59.38
1A1	Stationary fuel combustion	CH_4	8.59	0.48	5	100	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Fuel combustion	CH_4	9.44	1.69	5	100	100.12	0.00	0.00	0.00	0.01	0.00	0.00
1A3a	Civil aviation	CH_4	0.09	0.00	5	100	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1A3b	Road transportation	CH_4	20.60	35.36	5	40	40.31	0.01	0.00	0.00	0.05	0.00	0.00
1A3c	Other transportation	CH_4	0.07	0.13	5	100	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1A4a	Commercial/Institutional	CH_4	9.50	1.81	5	100	100.12	0.00	0.00	0.00	0.01	0.00	0.00
1A4b	Residential	CH_4	102.61	98.00	5	100	100.12	0.42	0.00	0.00	0.34	0.01	0.12
1A4c	Stationary	CH_4	28.72	0.66	5	100	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1B1	Fugitive Emissions from Solid Fuel Mining and transformation	CH_4	676.51	0.00	5	300	300.04	0.00	-0.01	0.00	0.00	-0.03	0.00
1B2	Fugitive Emissions from oil Extraction	CH_4	66.89	96.53	5	300	300.04	3.64	0.00	0.00	1.02	0.01	1.04
1B2	Fugitive Emissions from oil and natural gas production	CH_4	142.02	24.43	5	300	300.04	0.23	0.00	0.00	0.26	0.00	0.07
1B2	Fugitive Emissions from oil and natural gas Transmission and distribution	CH_4	5126.65	1293.79	10	100	100.50	73.36	-0.02	0.03	4.55	-0.16	20.72
4A	Enteric fermentation	CH_4	1883.0	1656.0	10	30	31.62	11.90	0.02	0.04	1.75	0.23	3.11
4B	Manure management	CH_4	122.0	74.0	10	50	50.99	0.06	0.00	0.00	0.13	0.01	0.02
3F	Field burning of Agricultural Residues (3.F)	CH_4	11.0	12.0	10	50	50.99	0.00	0.00	0.00	0.02	0.00	0.00
6A	Solid Waste Disposal Sides	CH_4	619.0	1073.0	30	30	42.43	8.99	0.02	0.03	1.13	0.63	1.67
6B1	Industrial Waste Water handling	CH_4	186.0	219.0	50	30	58.31	0.71	0.00	0.01	0.23	0.18	0.09
6B2	Domestic Waste Water handling	CH_4	240.0	167.0	5	30	30.41	0.11	0.00	0.00	0.18	0.01	0.03
1A1	Stationary fuel combustion	N_2O	26.89	2.77	5	100	100.12	0.00	0.00	0.00	0.01	0.00	0.00
1A2	Fuel combustion	N_2O	21.56	3.67	5	100	100.12	0.00	0.00	0.00	0.01	0.00	0.00
1A3a	Civil aviation	N_2O	0.00	0.00	5	150	150.08	0.00	0.00	0.00	0.00	0.00	0.00
1A3a i	International Aviation	N_2O	5.28	2.53	5	150	150.08	0.00	0.00	0.00	0.01	0.00	0.00

1A3b	Road transportation	N_2O	54.90	59.50	5	50	50.25	0.04	0.00	0.00	0.10	0.00	0.01
1A3c	Other transportation	N_2O	2.55	4.09	5	100	100.12	0.00	0.00	0.00	0.01	0.00	0.00
1A4a	Commercial/Institutional	N_2O	3.70	0.49	5	150	150.08	0.00	0.00	0.00	0.00	0.00	0.00
1A4b	Residential	N_2O	22.49	19.71	5	150	150.08	0.04	0.00	0.00	0.10	0.00	0.01
1A4c	Stationary	N_2O	5.33	0.14	5	150	150.08	0.00	0.00	0.00	0.00	0.00	0.00
2B2	Nitric Acid Production	N_2O	147.50	228.94	5	20	20.62	0.10	0.00	0.01	0.16	0.02	0.03
2G3	Medical Surgeries	N_2O	11.06	14.884	5	10	11.18	0.00	0.00	0.00	0.01	0.00	0.00
4B	Manure management	N_2O	365.0	313.0	50	100	111.80	5.31	0.00	0.01	1.10	0.22	1.26
4D1	Direct soil emissions	N_2O	1080.0	884.0	10	25	26.93	2.46	0.01	0.02	0.78	0.12	0.62
4D3	Indirect soil emissions	N_2O	637.0	530.0	50	50	70.71	6.09	0.01	0.01	0.93	0.36	1.00
3F	Field burning of Agricultural Residues	N_2O	26.0	29.0	10	50	50.99	0.01	0.00	0.00	0.05	0.00	0.00
6B2	Domestic Waste Water handling	N_2O	55.0	59.0	5	70	70.18	0.07	0.00	0.00	0.15	0.00	0.02
2F	Consumption of halocarbons and sulfur hexafluoride (Refrigeration and Air Conditioning Equipments)	**HFC**	0.00	155.33	5	25	25.50	0.07	0.00	0.00	0.14	0.02	0.02
2F	Consumption of halocarbons and sulfur hexafluoride (Emissions from Appliances (electrical equipment)	**SF6**	0.00	355.76	5	100	100.12	5.51	0.01	0.01	1.25	0.04	1.57
	Total emissions:		**40221.66**	**15180.54**		**Percentage uncertainty in total inventory:**		**522.10**					**143.79**
								22.85				**Trend uncertainty:**	**11.99**

ANNEX C. UNCERTAINTY VALUES OF ACTIVITY DATA AND EMISSION FACTORS

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
1A1	Electricity and Heat Production - Liquid Fuels	**CO_2**	According to IPCC GHG uncertainty for main activity electricity and heat production, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is less than 1%. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf (table 2.15). Therefore, the uncertainty was set at 1%.	According to the IPCC Guidelines, selecting a typical value for emission factors is within the 95%; confidence interval and uncertainty is less than 5%. Therefore, a value of 5% was selected.
1A1	Electricity and Heat Production - Gaseous fuels	**CO_2**	According to IPCC GHG uncertainty for main activity electricity and heat production, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is less than 1%. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf (table 2.15). Therefore, the uncertainty was set at 1%.	According to the IPCC Guidelines, selecting a typical value for emission factors is within the 95%; confidence interval and uncertainty is less than 5%. Therefore, a value of 5% was selected.
1A1	Heat Production and other Energy Industries - Solid Fuels	**CO_2**	According to IPCC GHG uncertainty for main activity electricity and heat production, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is less than 1%. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf (table 2.15). Therefore, the uncertainty was set at 1%.	According to the IPCC Guidelines, selecting a typical value for emission factors is within the 95%; confidence interval and uncertainty is less than 5%. Therefore, a value of 5% was selected.
1A2	Manufacturing Industries and Construction - solid fuels	**CO_2**	According to IPCC GHG uncertainty for Industrial combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 2-5%, but when data are based on extrapolation, uncertainty is about 3-10%. A complete official energy balance, according to international standards and requirements was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for the 2013 reference period). The energy balance for 1990 was also developed by Official Statistics Office, however it was mostly based on soviet standards and methodologies, and was not fully in line with EU requirements. Therefore, the uncertainty was set at 5%.	According to the IPCC Guidelines, for solid fuels, the value of 12.4% for uncertainty was selected
1A2	Manufacturing Industries and	**CO_2**	According to IPCC GHG uncertainty for Industrial combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 2-5%, but when data are based on extrapolation, uncertainty is about 3-10%. A complete official energy balance, according to international standards and requirements was	According to the IPCC Guidelines, for biomass, the value of 18.7% for uncertainty was selected

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
	Construction - biomass		developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for the 2013 reference period). The energy balance for 1990 was also developed by Official Statistics Office, however it was mostly based on soviet standards and methodologies and was not fully in line with EU requirements. Despite this, the uncertainty was set at 5%.	
1A2	Manufacturing Industries and Construction - liquid fuels	**CO_2**	According to IPCC GHG uncertainty for Industrial combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 2-5%, but when data are based on extrapolation, uncertainty is about 3-10%. A complete official energy balance, according to international standards and requirements was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for the 2013 reference period). The energy balance for 1990 was also developed by Official Statistics Office, however it was mostly based on soviet standards and methodologies and was not fully in line with EU requirements. Despite this, the uncertainty was set at 5%.	According to the IPCC Guidelines, for liquid fuels, the value of 6.1% for uncertainty was selected
1A2	Manufacturing Industries and Construction - Gaseous Fuels	**CO_2**	According to IPCC GHG uncertainty for Industrial combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 2-5%, but when data are based on extrapolation, uncertainty is about 3-10%. A complete official energy balance, according international standards and requirements was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for the 2013 reference period). The energy balance for 1990 was also developed by Official Statistics Office, however it was mostly based on soviet standards and methodologies and was not fully in line with EU requirements. Despite this, the uncertainty was set at 5%.	According to the IPCC Guidelines, for gaseous fuels, the value of 3.9% for uncertainty was selected
1A3a	Civil aviation	**CO_2**	According to the IPCC Guidelines, with complete survey data, the uncertainty may be very low (less than 5 percent) https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (3.69). Therefore, a value of 5% was selected.	According to the IPCC Guidelines and based of the expert assessment, uncertainty value of 4.2% was selected
1A3ai	International Aviation (International Bunkers) - Liquid Fuels	**CO_2**	According to the IPCC Guidelines, with complete survey data, the uncertainty may be very low (less than 5 percent) https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (3.69). Therefore, a value of 5% was selected.	According to the IPCC Guidelines and based of the expert assessment, uncertainty value of 4.2% was selected
1A3b	Road Transportat	**CO_2**	According to the IPCC Guidelines, with complete survey data, the uncertainty may be very low (less than 5 percent) https://www.ipcc-	According to the IPCC Guidelines and based of the expert assessment, uncertainty value of 3.1% was selected

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
	ion - Liquid Fuels		nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf. Therefore, a value of 5% was selected.	
1A3b	Road transportation - Gaseous Fuels	**CO_2**	According to the IPCC Guidelines, with complete survey data, the uncertainty may be very low (less than 5 percent) https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf. Therefore, a value of 5% was selected.	According to the IPCC Guidelines and based of the expert assessment, uncertainty value of 3.9% was selected
1A3c	Other transportation	**CO_2**	According to the IPCC Guidelines, with complete survey data, the uncertainty may be very low (less than 5 percent) https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf. Therefore, a value of 5% was selected.	Typical 5%.
1A3d	International water-borne navigation (International bunkers) - Liquid Fuels	**CO_2**	According to the IPCC Guidelines, with complete survey data, the uncertainty may be very low (less than 5 percent) https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf. Therefore, a value of 5% was selected.	According to the IPCC Guidelines and based of the expert assessment, uncertainty value of 4.2% was selected
1A4a	Commercial/Institutional - solid fuels	**CO_2**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia’s case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC Guidelines, for solid fuels, the value of 12.4% for uncertainty was selected
1A4a	Commercial/Institutional - liquid fuels	**CO_2**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia’s case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC Guidelines, for liquid fuels, the value of 6.1% for uncertainty was selected
1A4a	Commercial/Institutional - Gaseous Fuels	**CO_2**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia’s case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC Guidelines, for gaseous fuels, the value of 3.9% for uncertainty was selected
1A4a	Commercial/Institution	**CO_2**	According IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when	According to the IPCC Guidelines, for biomass, the value of 18.7% for uncertainty was selected

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
	al - biomass		data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	
1A4b	Residential - solid fuels	**CO_2**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC Guidelines, for solid fuels, the value of 12.4% for uncertainty was selected
1A4b	Residential - liquid fuels	**CO_2**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC Guidelines, for liquid fuels, the value of 6.1% for uncertainty was selected
1A4b	Residential - Gaseous Fuels	**CO_2**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC Guidelines, for gaseous fuels, the value of 3.9% for uncertainty was selected
1A4b	Residential - biomass	**CO_2**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC Guidelines, for biomass, the value of 18.7% for uncertainty was selected
1A4c	Stationary - solid fuels	**CO_2**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC Guidelines, for solid fuels, the value of 12.4% for uncertainty was selected

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
1A4c	Stationary-Liquid Fuels	**CO_2**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC Guidelines, for liquid fuels, the value of 6.1% for uncertainty was selected
1A4c	Stationary - Gaseous Fuels	**CO_2**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC Guidelines, for gaseous fuels, the value of 3.9% for uncertainty was selected
1A4c	Stationary - Biomass	**CO_2**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC Guidelines, for biomass, the value of 18.7% for uncertainty was selected
1B1	Fugitive Emissions from Solid Fuel Mining and transformation	**CO_2**	Coal mining data provided by GEOSTAT is reliable and, therefore, the uncertainty value of 5% was chosen. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_4_Ch4_Fugitive_Emissions.pdf (pg. 4.15, 4.16)	According to the IPPC methodology, using the typical emission factor for this category has a huge uncertainty value. Therefore, an uncertainty value of 300% was chosen. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf (pg. 4.15, 4.16)
1B2	Fugitive Emissions from Fuels - Oil and Natural Gas (Flaring, production, distribution)	**CO_2**	Data on Oil and Natural Gas was provided by the Oil and Gas Corporation and is reliable. Therefore, an uncertainty value of 5% was chosen	According to the IPPC methodology, using the typical emission factor for this category has huge uncertainty value. Due to the complexity of the oil and gas industry, it is difficult to quantify the net uncertainties in the overall inventories, emission factors and activity data. Therefore, an uncertainty value of 300% was chosen. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf (table 4.2.4, table 4.2.5)
2A1	Cement Production	**CO_2**	Activity data is quite accurate; therefore, its uncertainty value is within 5%.	Major source for emission factor uncertainty is associated with determining the CaO content of clinker. If clinker data are available, the uncertainty of the emission factor is equal to the uncertainty of the CaO fraction and the assumption is that it was all derived from

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
				CaCO3 (Table 2.3)122. According to the methodology, it is assumed that the content of CaO is standard, associated with 4-8% of uncertainty. That's why, the uncertainty of emission factors is about 5%.
2A2	Lime Production	**CO_2**	In Georgia, as far as lime production is scattered in many small enterprises, there is certain risk regarding full coverage. However, the National Statistics Office of Georgia (GEOSTAT),being the source for these data, has significantly improved data coverage in this area; nevertheless, according to the IPCC methodology the uncertainty could still be quite hig. Consequently, based on the experts' assessment, the uncertainty of activity data from this source is estimated as 20%.	The stoichiometric ratio is a precisenumber and, therefore, the uncertainty of the emission factor is the uncertainty of lime composition, in particular of the share of hydraulic lime that has 15% uncertainty in the emission factor (2% uncertainty in the types). Therefore, the total uncertainty value is 15%
2A3	Glass production		Glass production data are typically measured fairly accurately (+/-5 percent) for Tier 1 and Tier 2 approaches.	Because emissions are estimated based on quantity of melted glass in each manufacturing process and default emission factors, the uncertainty of Tier 2 is higher than Tier 3. The emission factors can be expected to have an uncertainty of +/- 10 percent.
2B1	Ammonia Production	**CO_2**	Activity data was collected from the National Statistics Office of Georgia (GEOSTAT), as well as from the enterprise Rustavi Chemical Fertilizers Plant, which are rather accurate data. Emissions are calculated based on the volume of consumed natural gas, as well as based on the produced ammonia amount. Based on the expert judgment, their uncertainty is within 5%.	Based on the 2006 IPCC, the only required fuel uncertainty is estimated from determining the parameters of the CO_2 emissions coefficient for manufacturing the unit weight ammonia, which is about 6-7%, when using the Tier 1 approach. In Georgia's case, based on the expert assessment, the overall uncertainty of the CO_2 emission coefficient is around 6%.
2C1	Cast Iron and Steel Production	**CO_2**	According to guideline, the most important type of activity data is the amount of steel produced; each method is applicable and national statistics should be available and likely have an uncertainty of ± 10 percent. Therefore, uncertainty value of 10% was selected.	According to the 2006 IPCC methodology[123] the default emission factors for iron and steel production usedmay have an uncertainty of ± 25 percent (see table 4.4).
2C2	Ferroalloys Production	**CO_2**	According to IPCC methodology, the most important type of activity data is the amount of ferroalloy production by product type and national statistics should be available and likely have an uncertainty less than 5 percent. The activity data were collected from the National Statistics Office of Georgia (GEOSTAT), as well as from the Metallurgy research Institute of Georgia. Therefore, the data are rather accurate. Based on the expert assessment, their uncertainty value is 5%.	In case of using the Tier 1 method, the uncertainty of emission standard coefficients is estimated within the25% range.

[122] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf (pg. 2.17)

[123] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf (pg. 4.30)

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
2D1	Lubricant Use	**CO_2**	Much of the uncertainty in emission estimates is related to the difficulty in determining the quantity of non-energy products used in individual countries, for which a default of 5 percent may be used in countries with well-developed energy statistics and 10-20 percent in other countries (PG. 5.10) https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf	The default ODU factors developed are very uncertain, as they are based on limited knowledge of typical lubricant oxidation rates. Expert judgment suggests using a default uncertainty of 50 percent.
5A	Forest land	**CO_2**	According to the IPCC methodology, uncertainties vary between 1-15% in 16 European countries (Laitat et al. 2000). Area data should be obtained using the guidance in Chapter 3 or from FAO (2000). Industrialized countries estimated an uncertainty in forest area as approximately 3%. In Georgia's case 5% uncertainty was selected.	In Finland, the uncertainty of basic wood density of pine, spruce and birch trees is up to 20% in studies of Hakkila (1968, 1979). The variability between forest stands of the same species should be lower or at most the same as for individual trees of the same species. In Finland, the uncertainty of biomass expansion factors for pine, spruce, and birch was approximately 10% (Lehtonen et al., 2003). In eight Amazon tropical forest inventory plots, combined measurement errors led to errors of 10-30% in estimates of basal area change over periods of less than 10 years (Phillips et al., 2002). The overall uncertainty of country-specific basic wood density values should be about 20%
5B	Cropland	**CO_2**	Activity data are quite accurate. Based on the expert assessment, its uncertainty value is within 10%.	The sources of uncertainty when using the Tier 1 method include the degree of accuracy in land area estimates and in the default biomass carbon increment and loss rates. Uncertainty is likely to be low (<10%) in estimates of area under different cropping systems since most countries annually estimate cropland area using reliable methods. A published compilation of research on carbon stocks in agroforestry systems was used to derive the default data provided in Table 5.1 (Schroeder, 1994). While defaults were derived from multiple studies, their associated uncertainty ranges were not included in the publication. Therefore, a default uncertainty level of +75% of the parameter value has been assigned based on IPCC methodology and expert judgment.
5C	Grassland	**CO_2**	Activity data are quite accurate. Based on the expert assessment, its uncertainty value is within 10%.	According to the IPCC methodology and based on the expert judgment, the default uncertainty value of 75% was selected.
1A1	Stationary fuel combustion	**CH_4**	Typical 5%.	According to the IPCC GPG document, Table 2.12 reads that the uncertainty boundary is within the 50%-150% interval. In Georgia's case the intermediate at 100% was selected.

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
				https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf
1A2	Fuel combustion	**CH_4**	Typical 5%.	According to the IPCC GPG document, Table 2.12 reads that the uncertainty boundary is within the 50%-150% interval. In Georgia's case the intermediate at 100% was selected. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf
1A3a	Civil aviation	**CH_4**	According to the IPCC Guidelines, with complete survey data, the uncertainty may be very low (less than 5 percent) https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (3.69). Therefore, a value of 5% was selected.	According to IPCC GHG methodology, the uncertainty of the CH4 emission factor may range between -57 and +100 percent. In Georgia's case, uncertainty value of 100% was selected. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (pg. 3.69)
1A3b	Road transportation	**CH_4**	Typical 5%.	Methane usually contributes less than 1% of the CO2-equivalent emissions from the transportation sector. Experts believe that there is an uncertainty of ±40% in the CH4 estimate. That's why uncertainty value of 40% was selected. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (pg. 3.29)
1A3c	Other transportation	**CH_4**	Typical 5%.	Typical 100%.
1A4a	Commercial/Institutional	**CH_4**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC GPG document, Table 2.12, the uncertainty boundary is within the 50%-150% interval. In Georgia's case the intermediate 100% was selected. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (pg.2.38)
1A4b	Residential	**CH_4**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about	According to the IPCC GPG document, Table 2.12, the uncertainty boundary is within the 50%-150% interval. In Georgia's case the intermediate 100% was selected. https://www.ipcc-

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
			5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (pg.2.38)
1A4c	Stationary	**CH_4**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC GPG document, Table 2.12, the uncertainty boundary is within the 50%-150% interval. In Georgia's case the intermediate 100% was selected. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (pg.2.38)
1B1	Fugitive Emissions from Solid Fuel Mining and transformation	**CH_4**	Coal mining data provided by GEOSTAT are reliable and, therefore, the uncertainty value of 5% was chosen. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf (pg. 4.15, 4.16), (table 4.2.4, table 4.2.5)	According to the IPPC methodology, using the typical emission factor for this category has a huge uncertainty value. Therefore, an uncertainty value of 300% was chosen. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf (pg. 4.15, 4.16), (table 4.2.4, table 4.2.5)
1B2	Fugitive Emissions from oil Extraction	**CH_4**	Data on Oil extraction are provided by the Oil and Gas Corporation and are reliable. Therefore, the uncertainty value of 5% was chosen.	According to the IPPC methodology, using the typical emission factor for this category has huge uncertainty value. Due to the complexity of the oil and gas industry, it is difficult to quantify the net uncertainties in the overall inventories, emission factors and activity data. Therefore, an uncertainty value of 300% was chosen. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf (table 4.2.4, table 4.2.5)
1B2	Fugitive Emissions from oil and natural gas production	**CH_4**	Data on gas production were provided by the Oil and Gas Corporation and are reliable. Therefore, an uncertainty value of 5% was chosen.	According to the IPPC methodology, using the typical emission factor for this category has huge uncertainty value. Due to the complexity of the oil and gas industry, it is difficult to quantify the net uncertainties in the overall inventories, emission factors and activity data. Therefore, an uncertainty value of 300% was chosen. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf (table 4.2.4, table 4.2.5)
1B2	Fugitive Emissions from oil and natural gas	**CH_4**	The data were calculated using analytical method, they were based on estimation and, therefore, an uncertainty value of 10% was chosen.	According to the IPPC methodology, 100% value of uncertainty was chosen for emission factors. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf (pg. 4.49, 4.50)

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
	Transmission and distribution			
4A	Enteric fermentation	**CH_4**	The activity data were taken from the official statistical publication and are reliable. Classification and distribution of cattle is not entirely consistent with the IPCC standard on dairy and non-dairy cattle, however, it could be assumed, that the data provided by GEOSTAT about "cows" and "other cattle" are in conformity with the classification of "dairy" and "non-dairy cattle", as cows were intended for exactly dairy purpose in the case of Georgia, and the rest for beef production. Therefore, the uncertainty of activity data is moderate and does not exceed of 10%.	As the emission factors for the Tier 1 method are not based on country-specific data, they may not accurately represent a country's livestock characteristics, and may be highly uncertain as a result. Emission factors estimated using the Tier 1 method are unlikely to be known more precisely than ± 30% and may be uncertain to ± 50%. In case of Georgia uncertainty of 30% was selected, as for activity data (heads of cattle by species), they should be considered as reliable, since they are based on Official Statistical Data from GEOSTAT.
4B	Manure management	**CH_4**	The uncertainty of activity data related to animal number is estimated at 10%, as it is based on official statistical data.	According to the IPCC GPG, 50% is taken for methane emissions-related uncertainty.
3F	Field burning of Agricultural Residues (3.F)	**CH_4**	According to IPCC 2006 methodology and based on expert assessment https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf (table 2.27, table 2.5, table 2.6), the value of 10% was selected.	According to IPCC 2006 methodology and based on the expert assessment https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf (table 2.27, table 2.5, table 2.6), the value of 50% was selected.
6A	Solid Waste Disposal Sides	**CH_4**	Calculations were made based on the IPCC 2006 methodology, Table 3.5; The final uncertainty of the activity data was estimated at 30%. https://www.ipccnggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf (pg. 3.27)	Calculations were made based on the IPCC 2006 methodology, Table 3.5; and similar calculations were performed in the SNC. The value of uncertainty for emission factor 30% was chosen.
6B1	Industrial Waste Water handling	**CH_4**	Calculations were made based on the IPCC 2006 methodology, Table 6.10 and similar calculations were performed in the SNC. The final uncertainty of the activity data was set at 50%. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf (pg. 6.23)	Calculations were made based on the IPCC 2006 methodology, Table 6.10 and similar calculations were performed in the SNC. The final uncertainty in emission factors was set at 30%.
6B2	Domestic Waste Water handling	**CH_4**	Calculations were made based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 6.7; The final uncertainty of the activity data was set at 5%. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf	Calculations were made based on the 2006 IPCC Guidelines (Table 6.7) and similar calculations were performed in the SNC. The final uncertainty in emission factors was set at 30%.

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
			V5_6_Ch6_Wastewater.pdf (pg. 6.17)	
1A1	Stationary fuel combustion	**N_2O**	Typical 5%.	According to the IPCC GPG document, Table 2.12 reads that the uncertainty boundary is within the 50%-150% interval. In Georgia's case the intermediate at 100% was selected. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf
1A2	Fuel combustion	**N_2O**	Typical 5%.	According to the IPCC GPG document, Table 2.12 reads that the uncertainty boundary is within the 50%-150% interval. In Georgia's case the intermediate of 100% was selected. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf
1A3a	Civil aviation	**N_2O**	According to the IPCC Guidelines, with complete survey data, the uncertainty may be very low (less than 5 percent). Therefore, a value of 5% was selected.	according to IPCC GHG methodology, the uncertainty of the N2O emission factor may range between -70 and +150 percent. Based on the expert assessment, uncertainty value of 150% was selected. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (pg. 3.69)
1A3ai	International aviation	**N_2O**	According to the IPCC Guidelines, with complete survey data, the uncertainty may be very low (less than 5 percent). Therefore, a value of 5% was selected.	According to IPCC GHG methodology, the uncertainty of the N2O emission factor may range between -70 and +150 percent. Based on the expert assessment, uncertainty value of 150% was selected. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (pg. 3.69)
1A3b	Road transportation	**N_2O**	Typical 5%.	Typical 50% https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (pg. 3.29). Nitrous oxide usually contributes approximately 3% to the CO2-equivalent emissions from the transportation sector. Theexpert judgment suggests that the uncertainty of the N2O estimate may be more than ±50%. The major source of uncertainty is related to the emission factors.
1A3c	Other transportation	**N_2O**	Typical 5%	Typical 100%
1A4a	Commercial/Institutional	**N_2O**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is	According to the IPCC GPG document, Table 2.12, uncertainty ranges from one-tenth of the mean value, to ten times the mean value that should be applied. In this case, an uncertainty value of 150% was

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
			about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	selected. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (pg.2.38)
1A4b	Residential	**N_2O**	According to IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC GPG document, Table 2.12, uncertainty ranges from one-tenth of the mean value, to ten times the mean value that should be applied. In this case, an uncertainty value of 150% was selected. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (pg.2.38)
1A4c	Stationary	**N_2O**	uncertainty of 5% was chosen	According to the IPCC methodology https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (pg.2.38), an uncertainty value of 150% was selected.
2B2	Nitric Acid Production	**N_2O**	The activity data are rather accurate. Based on the expert judgment its uncertainty value does not exceed 5%.	A new IPCC manual allows standard boundaries of 20% uncertainty assessment for medium-pressure technology plants
2G3	Medical Surgeries	**N_2O**	According to IPCC 2006 manual, activity data uncertainties are estimated based on the expert judgment. Uncertainty value of 5% was estimated https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_8_Ch8_Other_Product.pdf (pg. 8.37)	According to IPCC 2006 manual, uncertainties are estimated byased on the expert judgment. Uncertainty value was estimated at 10%. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_8_Ch8_Other_Product.pdf (pg. 8.37)
4B	Manure management	**N_2O**	The uncertainty of activity data for nitrous oxide emissions calculation in the manure management sector were estimated at 50%, as there is no exact information about the management systems.	According to IPCC GPG, the uncertainty for emission factors was estimated at 100%
4D1	Direct soil emissions	**N_2O**	The activity data were collected from National Statistics Office of Georgia (GEOSTAT), which is a competent source and quite accurate. Therefore, 10% was selected as the indicator of uncertainty.	The uncertainty for emission factors were taken from the standard range of the IPCC GPG, there were alsobased on the expert assessment and are equal to 25%.
4D3	Indirect soil emissions	**N_2O**	The uncertainty of activity data is also quite high and related to the assumption on the percentage leached. In addition, the nitrogen content in fertilizers also has uncertainty. Finally, the uncertainty of activity data was set at 50%.	According to IPCC methodology and expert judgment emission factor uncertainties are at least in order of magnitude and volatilisation fractions of about +/−50%.
3F	Field burning of Agricultural Residues (3.F)	**N_2O**	According to IPCC 2006 methodology and based on expert assessment https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf (table 2.27, table 2.5, table 2.6), the value of 10% was selected.	According to IPCC 2006 methodology and based the on expert assessment https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf (table 2.27, table 2.5, table 2.6), the value of 50% was selected.

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
6B2	Domestic Waste Water handling	**N_2O**	The only national value for the emission calculation formula is the number of the populations, for which the uncertainty is estimated within 5% limits. Consequently, 5% of uncertainty value was chosen.	According to IPCC methodology and the expert judgment, emission factor uncertainties are estimated at 70%.
2F	Consumption of halocarbons and sulfur hexafluoride (Refrigeration and Air Conditioning Equipment)	**HFC**	Activity dataare relatively accurate. Based on the expert judgment, its uncertainty value is 5%	According to the IPCC GPG, the uncertainty level for standard coefficients of emission is estimated at 25%.
2F	Consumption of halocarbons and sulfur hexafluoride (Emissions from Appliances (electrical equipment)	**SF6**	Activity data are relatively accurate. Based on the expert judgment, its uncertainty value is 5%	According to the IPCC GPG, tier 1 estimates are set at an uncertainty level of 100% or more, representing an estimate of actual emissions. Therefore, the value of 100% was selected.

mepa.gov.ge

info@mepa.gov.ge

+995(32) 2 47 01 01
+995(32) 2 37 80 09

Marshal Gelovani Av. 6, 0159, Georgia, Tbilisi

2020