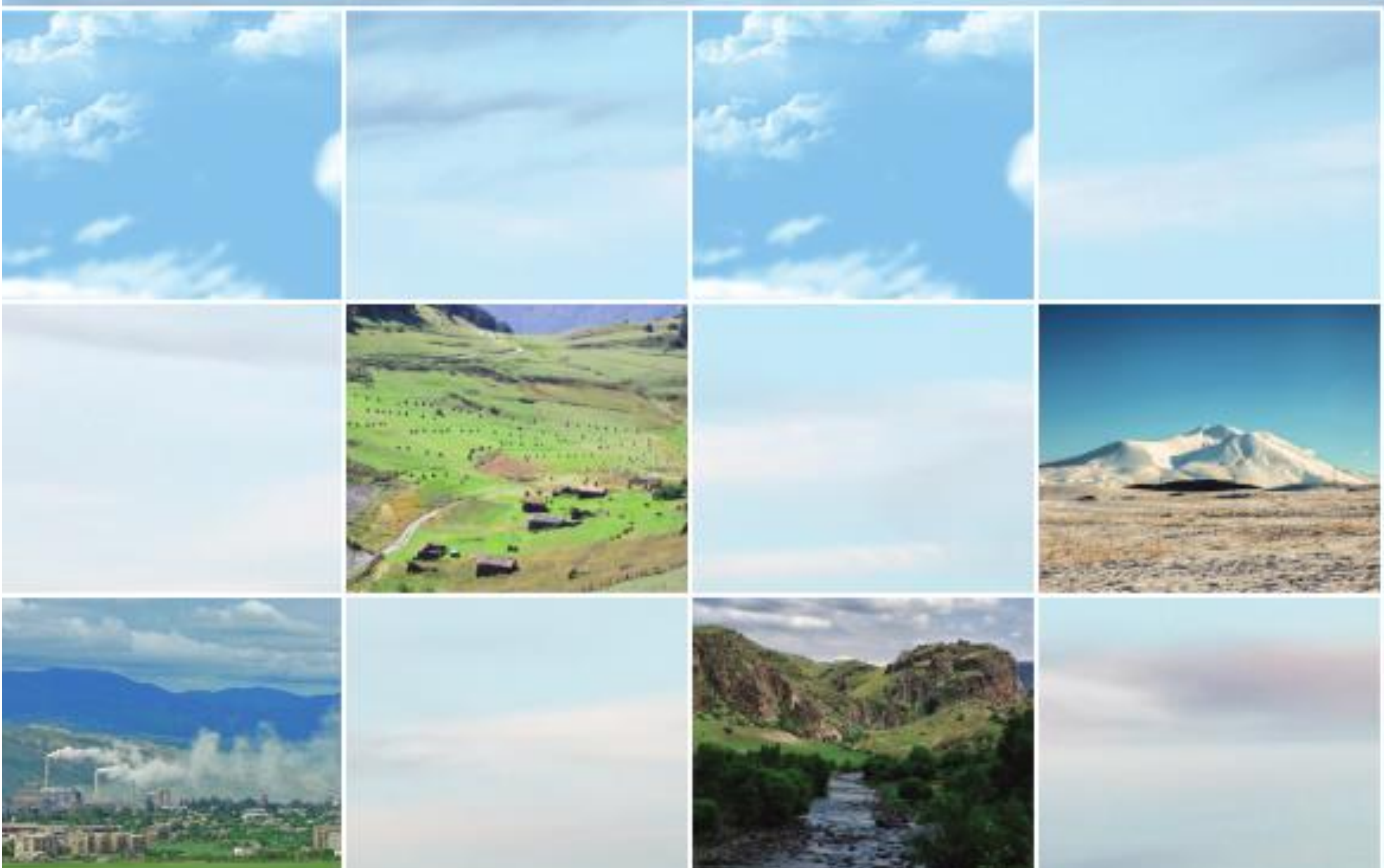
GHGs National Inventory Report of Georgia

2010-2013



GHGs National Inventory Report of Georgia

2010-2013

Tbilisi

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The National Inventory Report of GHG emissions to the UNFCCC was prepared by a group of decision makers, experts and other stakeholders, representing: the Ministry of Environment and Natural Resources Protection of Georgia and its Environmental Information and Education Center, the Think Tank "World Experience for Georgia", Ilia State University, independent national and international sector experts.

We would like to recognize the partners who have contributed to the projects outlined in this publication, the United Nations Development Programme in Georgia (www.ge.undp.org) and the Global Environment Facility (www.thegef.org) for their support and financial contribution to these projects.

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)
CRF – Common Reporting Format
DOC – Degradable Organic Carbon
EF – Emission Factor
EIA – Environmental Impact Assessment
FAOSTAT – Food and Agriculture Organization Statistics Office
GAM – Global Average Method
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
MSW – Municipal Solid Waste
NG – Natural Gas
NMVO – Non-Methane Volatile Organic Compounds
NSO – National Statistics Office
SNC – Second National Communication
TNC – Third National Communication
C – Carbon
CaO – Lime
CH_4 – Methane
CO – Carbon Oxide
CO_2 – Carbon Dioxide
HFC – Hydrofluorocarbons
N_2O – Nitrous Oxide
PFC – Perfluorocarbons
SF_6 – Sulphur Hexafluoride
SO2 – Sulphur Dioxide
Gg – Gigagram (10^9 gram=1000 ton)
hl – Hectoliter (100 Litre)
PJ – Peta Joule (10^{15} Joule)
TJ – Tera Joule (10^{12} Joule)

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1. INTRODUCTION

1.1. OVERVIEW

On May 9, 1992, countries worldwide adopted the UN Framework Convention on Climate Change (UNFCCC). "The ultimate objective of this Convention is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a 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."

The ability of the International Community to achieve the set objective, by reducing Greenhouse Gases (GHGs) emission, depends on of 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] – information about national GHGs emissions and sources of removal. Up to 2010[2], the main reporting mechanism for Non-Annex 1 countries of the Convention was National Communication. 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[4]) about the trends of GHG emission and the planned mitigation activities for climate change.

In Georgia, the first GHG inventory was performed based on the 1980-1996 data, as part of the preparation of the First/Initial National Communication (FNC, 1997-1999). The Second National Communication (SNC, 2006-2009) comprised the period of 1998-2006. The 2007-2011 GHG inventory was performed as part of the Third National Communication (TNC, 2012-2015). The 2010-2013 GHG inventory was prepared for the First Biennial Update Report of Georgia to UNFCCC. The results of 2010-2011 were recalculated for the various sectors.

The present report describes the results of the Fourth National Inventory of greenhouse gases for the period 2010-2013. 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:

- 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.
- IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (2003) – hereafter reffered to as IPCC GPG-LULUCF.
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories[7] (hereafter referred to as IPCC 2006) have also been used; although these are not mandatory guidelines, they do comprise a lot of additional valuable material.

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[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, at which 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] BUR (Biennial Update Report).

[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/

For the compilation of the inventory, UNFCCC NAI Inventory Software v 1.3.2 (Excel based) was used. According to the Common Reporting Format (CRF) of the IPCC Methodology, inventories cover six sectors, as follows:

Energy (CRF Sector 1)
Industrial Processes (CRF Sector 2)
Solvents and other Product Use (CRF Sector 3)
Agriculture (CRF Sector 4)
Land use, Land- Use Change and Forestry[8] (CRF Sector 5)
Waste (CRF Sector 6)

The 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).

These gases are often referred to as Six Greenhouse Gases, although HFCs and PFCs actually represent groups of gases. Each gas has its individual contribution to the Greenhouse Effect. The contribution of mixture of gases in global warming depends on the gases and their fraction in the mixture. The strongest gases are SF_6, HFCs and PFCs. Methane captures 21 times more heat than carbon dioxide, while nitrous oxide captures 310 times more.

For the control of greenhouse gas emissions, the unit characterizing the ability of gases to capture heat – Global Warming Potential (GWP) – was adopted; it depicts the emission of specific gases in CO_2 equivalents. The precise definition of this concept is debatable. For example, GWP can be expressed as full effect of warming over a certain period, e.g., over 20, 100 or 500 years. According to the IPCC methodology, GWP values over a 100-year horizon – indicated in the IPCC Second Assessment Report[9] – are used. The values of the GWP of greenhouse gases are shown in the Table below.

TABLE 0-1 GLOBAL WARMING POTENTIAL (GWP) OF DIRECT GREENHOUSE GASES

Gas	Lifetime , years	100-years Horizon GWP
CO_2	variable (50-200)	1
CH_4	12±3	21
N_2O	120	310
HFC:		
HFC-23	264	11700
HFC-32	5.6	650
HFC-125	32.6	2800
HFC-134a	10.6	1300
HFC-143	48.3	3800
HFC-152	1.5	140

Gas	Lifetime, years	100-years Horizon, GWP
HFC-227	36.5	2900
HFC-236	209	6300
HFC-245	6.6	560
PFC:		
CF_4	50000	6500
C_2F_6	10000	9200
C_3F_8	2600	7000
C_4F_{10}	2600	7000
C_6F_{14}	3200	7400
SF_6	3200	23900

The Fourth National Inventory of Georgia reviews all the above-listed direct gases stipulated by the Convention and indirect greenhouse gases, such as: Nitrogen Oxides (NO_X), Carbon

[7]IPCC 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, EGgleston 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

[8]Hereinafter referred to as LULUCF

[9] IPCC Second Assessment - Climate Change 1995. IPCC, Geneva, Switzerland. pp 64

Monoxide (CO), and Non-Methane Volatile Organic Compounds (NMVOCs). The IPCC methodology, recommends to calculate emissions of Sulphur Dioxide (SO_2) as well.

In the Tables containing inventories results, following IPCC's recommendations, the following

K (Kilo) - 10^3

M (Mega) -10^{-6}

G (Giga) -10^{-9}

T (Tera) -10^{12}

P (Peta) -10^{15}

Examples: 1 Gigagram (Gg) =10^9 Grams= 10^6 kilograms (kg) =10^3 Tonnes (t)

1 Gigajoule (GJ) = 10^9 Joules (J)

1 Terajoule (TJ) =10^{12} Joules (J) =10^3 Gigajoules (GJ)

1 Petajoule (PJ) = 10^{15} Joules (J) = 10^6 Gigajoules (GJ)

prefixes were adopted for the units of amounts of greenhouses gass emissions.

The inventory work team at the Environmental Information and Education Center[10], the Climate Change Service unit of the Ministry of Environment and Natural Resources Protection (MoENRP) of Georgia, Think Tank "World Experience for Georgia[11]" (Quality Assurance, Quality Control), and invited experts (International Expert in LULUCF sector), participated in the preparation of Georgia's Fourth GHGs National Inventory Report.

1.2. INSTITUTIONAL FRAMEWORK OF THE INVENTORY

The Ministry of Environment and Natural Resources Protection of Georgia (MoENRP) is the key governmental body responsible for the development of climate change policies. It is also responsible for the greenhouse gas inventory in Georgia, but due to a lack of human and financial resources, the inventory cannot be performed without external assistance.

This inventory was conducted within the framework of the First Biennial Update Repot to the UNFCCC, which the country prepares with the financial assistance provided by the Global Environment Facility (GEF). The inventory, at this stage, is conducted with support of UNDP Georgia, which acts as the GEF Implementing Agency for the project, assisting the country for the entire project length to implement the activities set forth, and monitoring and supervising the project on behalf of the GEF.

Under the grant agreement between UNDP and the think tank World Experience for Georgia (WEG), the latter provided quality assurance and quality control for the GHGs emission inventory process.

The Environmental Information and Education Center of the MoENRP was the main implementing organ of the inventory project. It hired the experts, including local and international experts to prepare GHGs emission inventory.

The staff of the Climate Change Service of the MoENRP conducted trainings on GHGs emission inventory methodologies for the interns of the center.

[10] www.eiec.gov.ge
[11] www.weg.ge

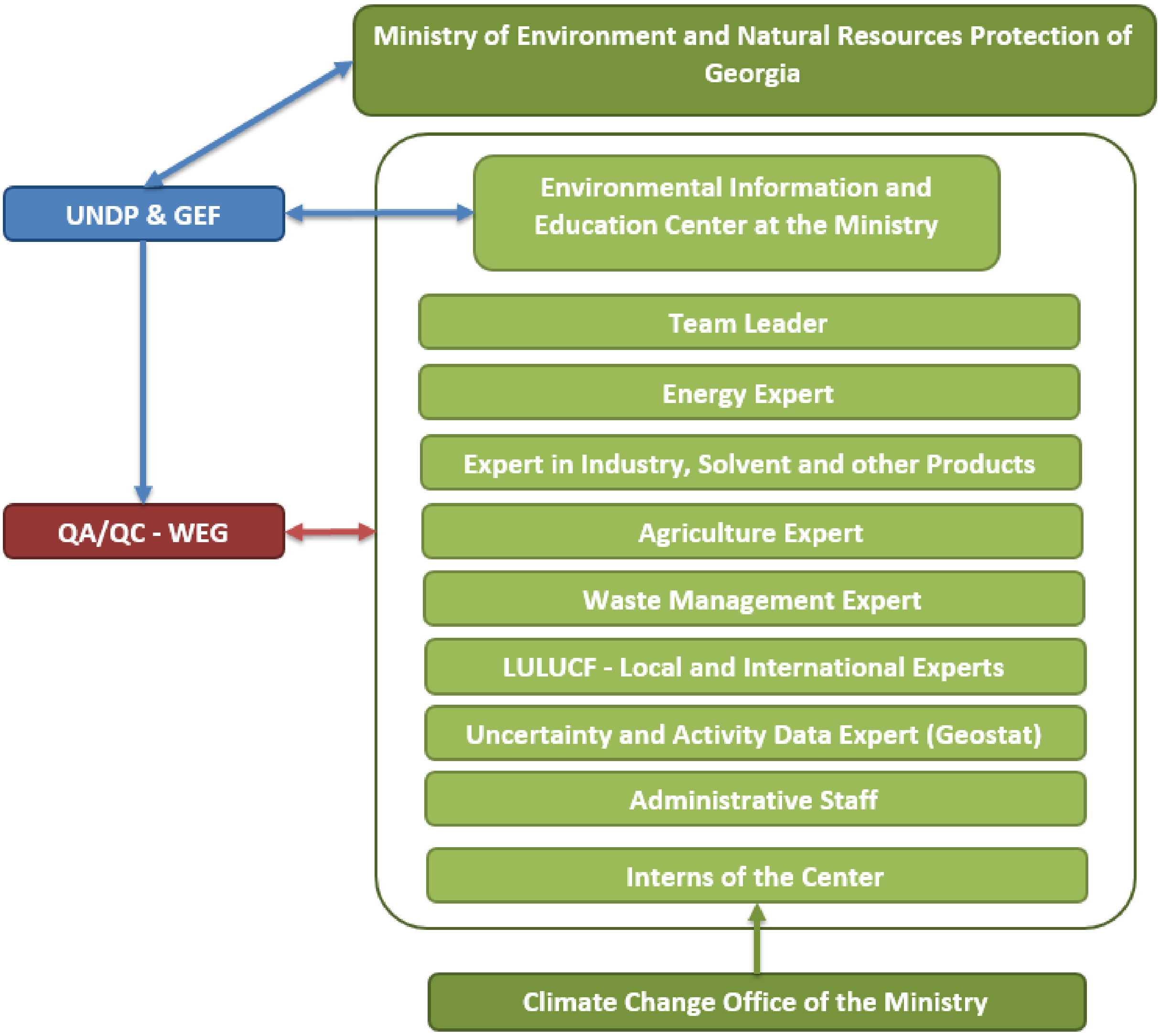


FIGURE 0.1- INSTITUTIONAL FRAMEWORK OF THE GHGS INVENTORY IN GEORGIA

1.3. DESCRIPTION OF KEY CATEGORIES

In the country's national inventory, certain source categories are particularly significant in terms of their contribution to the overall uncertainty of the inventory. It is important to identify these key source categories to prepare the best possible estimates for those categories. The methodology for the assessment of key source-categories of greenhouse gases emission is described in IPCC GPG Chapter 7. According to the IPCC definition, key source categories are those that, when summed together in descending order of magnitude of the level assessment, add up to over 95% of the total. It is important that the main efforts in the national inventory of greenhouse gases process are directed towards the improvement of inventory of the main key source-categories and the reduction of the uncertainty of their emissions.

This Chapter provides the analysis of key sources of greenhouse gas emission in Georgia for 2010-2013, for absolute values of emissions (emission level analysis), as well as for the trends.

For the identification of key source-categories, the share of individual source-categories emission (converted to CO_2 eq.) in emissions overall (excluding LULUCF Sector) is calculated according to absolute level of emissions (level assessment). Following the calculation of percentage contribution of each source-category, the percentage contribution of source categories as part of total emission is ranked in descending order. Next, the cumulative total of percentage shares is calculated. Among the source-categories, the sum of the contribution, of

which in the reviewed year is equal to or higher than 95%, are considered as key source-categories.

According to the trend assessment method, a source-category/sink is considered a key source-category if the trend differs considerably from the trend of total emissions and if it is a significant source-category/sink. For this assessment, the trend of a source-category is calculated for each source-category as the difference of the values of emissions/removals derived from this source-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 source-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 source-category emission, i.e., a level assessment is performed. Specifically, the total emission trend is subtracted from the assessed source-category trend and is multiplied by the value of the level (share), obtained for this source-category by the “level assessment” calculated for the base year. Derived values for all source-categories are summed and the share of each category, as part of this total, is calculated. Thus, a key source-category would include a source-category for which the difference between the total inventory trend and the source category trend, according to the source-category “level” in the base year, is significant.

As the structure and management principles of Georgia’s economy in 1990 were categorically different compared to now, using 1990 as a base year would identify those source-categories that underwent the most structural and essential changes, following the breakup of the Soviet Union, and would not be informative for assessing current trends and processes of emissions. The current inventory was conducted for the 2010-2013period. Hence, 2010 has been used as a base year for trend assessment. The derived results were arranged in a descending order and cumulative totals were calculated. The sources of which the cumulative total is equal to, or higher than 95% of the overall emission (in CO_2 eq.) were determined to be a key source-category in terms of the trend.

The identified key source-categories are presented in Table 1-2. The total amount of emissions in 2013 is 16,679 Gg CO_2eq. and the cumulative value of 95% comprises 97.6% of overall emissions (excluding the LULUCF Sector).

TABLE 0-2 KEY SOURCE-CATEGORIES OF GEORGIA’S GHG INVENTORY ACCORDING TO 2013 - LEVEL AND TREND ASSESSMENT APPROACHES

Ref	IPCC Source Categories	GHG	2013 Emissions (Gg CO2 eq)	Level Assessment (%)	Trend Assessment 2010-2013 (%)	Reason to Select as Key-category
1B2	Fugitive Emissions from Natural Gas Transmission and Distribution	**CH4**	1,805	10.6%	1.4%	Level, Trend
4A	Enteric Fermentation	**CH4**	1,351	7.9%	4.1%	Level, Trend
1A2	Manufacturing Industries and Construction - Solid Fuel	**CO2**	1,322	7.7%	10.8%	Level, Trend
1A3b	Road Transport - Diesel	**CO2**	1,223	7.2%	2.6%	Level, Trend
1A3b	Road Transport - Gasoline	**CO2**	1,148	6.7%	9.0%	Level, Trend
1A4b	Residential - Gas	**CO2**	999	5.9%	0.1%	Level, Trend

Ref	IPCC Source Categories	GHG	2013 Emissions (Gg CO2 eq)	Level Assessment (%)	Trend Assessment 2010-2013 (%)	Reason to Select as Key-category
1A1	Gas for Electricity and Heat Production	**CO2**	950	5.6%	8.5%	Level, Trend
2A2	Lime Production	**CO2**	891	5.2%	15.2%	Level, Trend
6A	Solid Waste Disposal Sides	**CH4**	880	5.2%	4.1%	Level, Trend
2B2	Nitric Acid Production	**N2O**	824	4.8%	3.6%	Level, Trend
4D1	Direct Soil Emissions	**N2O**	663	3.9%	1.1%	Level, Trend
2A1	Cement Production	**CO2**	600	3.5%	4.9%	Level, Trend
1A3b	Road Transport - Gas	**CO2**	490	2.9%	8.5%	Level, Trend
4D3	Indirect Emissions	**N2O**	437	2.6%	0.9%	Level, Trend
2C2	Ferroalloys Production	**CO2**	431	2.5%	0.3%	Level, Trend
1A2	Manufacturing Industries and Construction - gas	**CO2**	389	2.3%	0.1%	Level, Trend
4D2	Pasture Range and Paddock	**N2O**	366	2.1%	1.1%	Level, Trend
2B1	Ammonia Production	**CO2**	251	1.5%	0.4%	Level, Trend
1A4a	Commercial and Public Services - gas	**CO2**	249	1.5%	0.3%	Level, Trend
6B2	Domestic Waste Water handling	**CH4**	235	1.4%	1.1%	Level, Trend
1A2	Manufacturing Industries and Construction - Liquid Fuel	**CO2**	212	1.2%	3.4%	Level, Trend
2F	Consumption of Halocarbons and Sulfur Hexafluoride (Refrigeration and Air Conditioning Equipments)	**HFC**	208	1.2%	0.6%	Level, Trend
1A3c	Other Transportation	**CO2**	202	1.2%	1.0%	Level, Trend
4B	Manure Management	**N2O**	152	0.9%	0.2%	Level, Trend
1A4b	Residential - Liquid Fuels	**CO2**	41	0.2%	5.6%	Trend
1A4c	Agriculture, Fishing and Forestry - liquid fuels	**CO2**	28	0.2%	1.8%	Trend
1A5	Other (Not Elsewhere Specified)	**CO2**	12	0.1%	5.4%	Trend
1A4c	Agriculture, Fishing and Forestry - Gas	**CO2**	3	0.0%	1.9%	Trend

As can be seen from the Table, fugitive emissions from Natural Gas Transportation and Distribution Sector is leading, according to level and trend assessments. If the share of uncertainty of emissions of this sector in the overall uncertainty of the inventory is the highest, it becomes evident that this sector should be considered a priority, and the ways for the improvement of its methodology, activity data and emission factors, should be identified.

According to the level assessment, the enteric fermentation ranks second (8%), while according to trend assessment – lime production (15%) and solid fuel consumption in manufacturing industry (11%) are most significant source-categories. Consumption of gasoline, diesel and gas in road transport are key source categories as well.

The Industrial Processes sector is represented by the production of lime, cement, nitrous acid, ferroalloys, and ammonia. In the agriculture sector, key categories are enteric fermentation, direct soil emissions, idirect emissions, pasture range and paddock, and manure management (N_2O). The Waste Sector is represented by methane emissions from the solid waste sector and domestic waste water, handling key source categories.

Table 1-3 shows the results of Key source-categories of Georgia's GHG inventory for 2013 year including LULUCF sector.

TABLE 0-3 - KEY SOURCE-CATEGORIES OF GEORGIA'S GHG INVENTORY ACCORDING TO 2013 LEVEL AND TREND ASSESSMENT APPROACHES (INCLUDING LULUCF)

Ref	IPCC Source Categories	GHG	2013 Emissions (Gg CO2 eq)	Level Assessment (%)	Trend Assessment 2010-2013 (%)	Reason to select as Key-category
5A	Forest Land	**CO2**	5502.00	21%	10%	Level, Trend
5C	Grassland	**CO2**	2470.00	9%	7%	Level, Trend
1B2	Fugitive Emissions from Natural Gas Transmission and Distribution	**CH4**	1804.7	7%	1%	Level, Trend
4A	Enteric Fermentation	**CH4**	1350.9	5%	2%	Level, Trend
1A2	Manufacturing Industries and Construction - Solid Fuel	**CO2**	1322.2	5%	10%	Level, Trend
1A3b	Road Transport - Diesel	**CO2**	1223.2	5%	1%	Level
1A3b	Road Transport - Gasoline	**CO2**	1148.0	4%	6%	Level, Trend
1A4b	Residential - Gas	**CO2**	999.2	4%	1%	Level, Trend
5B	Perennial Crops	**CO2**	963.00	4%	3%	Level, Trend
1A1	Gas for Electricity and Heat Production	**CO2**	950.3	4%	8%	Level, Trend
2A2	Lime Production	**CO2**	890.93	3%	13%	Level, Trend
6A	Solid Waste Disposal Sides	**CH4**	879.9	3%	2%	Level, Trend
2B2	Nitric Acid Production	**N2O**	824.41	3%	2%	Level, Trend
4D1	Direct Soil Emissions	**N2O**	663.0	3%	0%	Level
2A1	Cement Production	**CO2**	599.95	2%	5%	Level, Trend

Ref	IPCC Source Categories	GHG	2013 Emissions (Gg CO2 eq)	Level Assessment (%)	Trend Assessment 2010-2013 (%)	Reason to select as Key-category
1A3b	Road Transport - Gas	**CO2**	490.4	2%	7%	Level, Trend
4D3	Indirect Emissions	**N2O**	437.1	2%	0%	Level
2C2	Ferroalloys Production	**CO2**	430.71	2%	0%	Level
1A2	Manufacturing Industries and Construction - Gas	**CO2**	388.6	1%	0%	Level
4D2	Pasture Range and Puddock	**N2O**	366.0	1%	0%	Level
2B1	Ammonia Production	**CO2**	250.68	1%	0%	Level
1A4a	Commercial and Public Services - Gas	**CO2**	249.0	1%	0%	Level
6B2	Domestic Waste Water Handling	**CH4**	235.2	1%	1%	Level, Trend
1A2	Manufacturing Industries and Construction - Liquid Fuel	**CO2**	212.3	1%	3%	Level, Trend
2F	Consumption of Halocarbons and Sulfur Hexafluoride (Refrigeration and Air Conditioning Equipments)	**HFC**	208.03	1%	1%	Level, Trend
1A4b	Residential - Liquid Fuels	**CO_2**	40.5	0%	4%	Trend
1A5	Other (Not Elsewhere Specified)	**CO_2**	12	0%	4%	Trend
1A4c	Agriculture, Fishing and Forestry - Gas	**CO_2**	3.3	0%	2%	Trend

2. GREENHOUSE GASES EMISSION TRENDS IN 1990-2013

2.1. DESCRIPTION AND ANALYSIS OF AGGREGATE EMISSION TRENDS

Greenhouse gases (CO_2, CH_4, N_2O, HFC and SF_6) emission trends for 1990-2013, without consideration of the LULUCF sector, are provided in Table 2.1 (Gg CO_2 eq.). In 1990, these emissions totaled 47,187 Gigagrams in CO_2 equivalent. Due to the breakup of the economic system of the Soviet period, emissions started to fall sharply and reached a minimum level by 1995 (8,799 Gg CO_2 eq.). From 1996, emissions started to rise, but the rate of the rise was considerably lower than the declining trend during 1990-1995. It should be noted that 1996-1997 were characterized by relatively higher emissions; this is due to high margin of error of the activity data in the Transport sector[12]. Without consideration of these two years, the trend is consistently increasing until 2007, when economic growth reached its peak. However, until 2010 emissions are again characterized by a declining trend. This was caused by several factors, of those most important is economic recession resulting from the global economic crisis, the 2008 war, and the rise of the share of hydrogenation in the electricity generation sector over these years. In 2011, sudden and extremely rapid increase of emissions was observed (26% as compared to a previous year) in Georgia, due to a joint effect of several factors. These are: economic revival, increased demand for electricity, and a hydrological year that was relatively low in water, as well as the increase of coal consumption in the processing industry sector. A more detailed analysis of greenhouse gases trends by gases, as well as by sectors, is provided in the following chapters.

The data on the sources of emission and removal of greenhouse gases from the LULUCF Sector are given in Table 2-2. In Georgia, this sector had a net sink of greenhouse gases during 1992-2013, except 2004, in which net source of emissions were observed. This sharp change is mainly attributed to the cropland category, in particular orchards in perennial plants. According to specified data, carbon dioxide emitted in 2004 in this sector was 37 113 GgCO_2, which influenced the whole sector trend, turning the sector into a carbone dioxide emitter. Changes in land cadastre data in 2004 caused these, as they specified the boundaries of perennial orchards, and areas covered with perennial crops were almost halved. It can be said, with high probability, that these areas were not reduced in a single year, a process steadily underway in prior years as well. As a result, it needs to be analyzed and respectively adjusted in the future. Overall, the sink capacity of the LULUCF sector fluctuates between (-882) Gg CO2 eq and (-7,091) Gg CO2 eq, showing a stable trend.

Without consideration of the LULUCF Sector, 2013 greenhouse gas emissions in Georgia totaled 16,679 Gg in CO_2 equivalent, and 12,555 Gg CO_2eq when taking this sector into account.

[12]Greenhouse Gases National Inventories Report, 2[nd] National Communication, Tbilisi, 2008. Pg. 24-25.

TABLE 2-1 GHG EMISSION TRENDS IN GEORGIA IN 1990-2013 (GG CO_2-EQ.)

Gas/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO2	38 543	29 947	18 078	9 727	6 145	4 177	6 875	7 339	3 373	3 680	3 710
CH4	5 920	5 030	5 827	4 689	3 952	3 222	3 393	4 445	4 510	4 468	5 230
N2O	2 724	2 459	1 996	1 624	1 297	1 401	2 003	2 168	1 703	2 058	1 833
HFC								33	40	85	90
SF6								0.02	0.02	0.02	0.03
Total	**47 187**	**37 436**	**25 902**	**16 040**	**11 394**	**8 799**	**12 272**	**13 985**	**9 625**	**10 290**	**10 864**

Gas | Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
CO2	3 880	3 685	3 936	4 847	5 047	6 250	7 161	7 116	6 613	6,694	9,225	9,851	9,547
CH4	4 579	4 453	4 782	4 755	4 439	6 017	5 592	5 075	4 477	4,107	4,568	4,939	4,700
N2O	1 728	2 075	2 181	1 989	2 402	2 083	1 881	1 650	2 030	2,000	1,990	2,079	2,223
HFC	97	112	152	176	221	279	368	467	547	138	238	354	208
SF6	0.03	0.03	0.03	0.03	0.03	0.05	0.06	0.14	0.17	0.22	0.25	0.27	0.28
Total	**10 284**	**10 326**	**11 051**	**11 767**	**12 110**	**14 628**	**15 002**	**14 309**	**13 667**	**12,939**	**16,022**	**17,224**	**16,679**

TABLE 2-2 GHG EMISSIONS AND ABSORPTION TRENDS IN GEORGIA IN LAND USE, CHANGES IN LAND USE AND FORESTRY SECTOR IN 1990-2013 (GG CO2EQ.)

Source	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CO_2 emission	2673	2547	2508	2508	2508	2511	2525	2469	2468	2470
CO_2 removal	-9764	-9111	-9145	-3390	-3900	-7441	-7117	-8884	-8556	-8626
Net removals	**-7091**	**-6564**	**-6637**	**-882**	**-1392**	**-4930**	**-4592**	**-6415**	**-6088**	**-6156**

Source	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
CO_2 emission	2470	2470	2470	2470	2470	2470	2470	2470	2472	2470	2472	2471
CO_2 removal	-7993	-8831	30423	-7363	-7643	-6568	-6660	-6911	-6342	-6678	-6544	-6594
Net removals	**-5523**	**-6361**	**32893**	**-4893**	**-5173**	**-4098**	**-4190**	**-4441**	**-3869**	**-4208**	**-4073**	**-4124**

2.2. EMISSION TRENDS BY SECTORS

Emission trends by sectors over 1990-2013 are provided in figure 2.1, which comprises all sectors[13], except for the LULUCF Sector[14]. And the change of the contribution of each sector in overall emissions (excluding LULUCF) is provided in FIG. 2.1. As can be seen from the Table and the Figure, energy is the dominant sector, and it accounts for more than half of total emissions in that period. Following the breakup of the Soviet Union, the contribution of the agricultural sector in total emissions grows gradually, and it ranks second in 1992-2006. From 2007, industrial processes gained and rank second. In 2013 the contribution of the industry Sector in total emissions was 20%, while the share of agriculture was 16%.

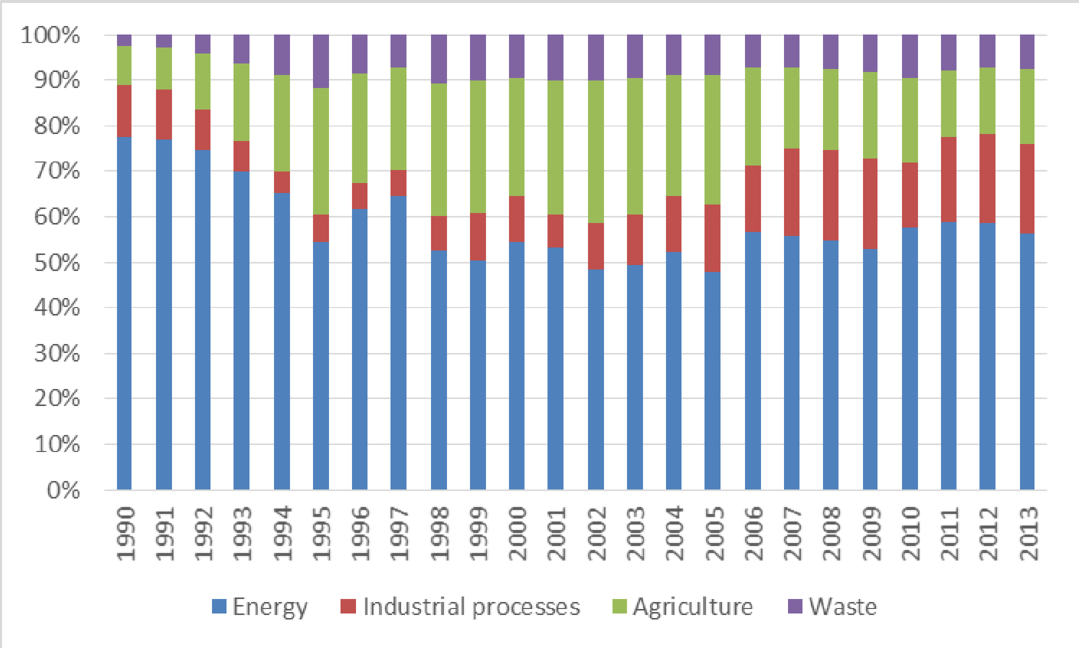


FIG. 2.1. THE SHARE OF SECTORAL EMISSIONS IN TOTAL EMISSIONS OF THE COUNTRY (WITHOUT LULUCF), 1990-2013.

Emissions from the energy sector in 2013 were 56% of the total emissions (except for the land use sector). In 2013, energy sector emissions were 3.9 times lower compared to 1990, while they increased by 1.6 relative to 2000. The collapse of the Soviet economy, halting of the industry and sharp deterioration of living conditions during 1990-1995, resulted in the reduction of overall emissions. Since 1996, emissions varied and started a gradual ascend from 2002. FIG. 2.2 shows energy sector emissions during 1990-2013. Economic progress, improvement of living conditions, increase in the quantity of transport, and a fast rate of gasification, are the factors influencing the energy sector emission trend during 2001-2007. During 2008-2009, emissions declined, due to an economic recession as a result of the global economic crisis and the 2008 war.

[13]Emissions from the Industrial Processes Sector also comprise emissions from the consumption of solvents and other products.

[14] Emissions and removal from the LULUCF sector are provided in Table 2-2 .

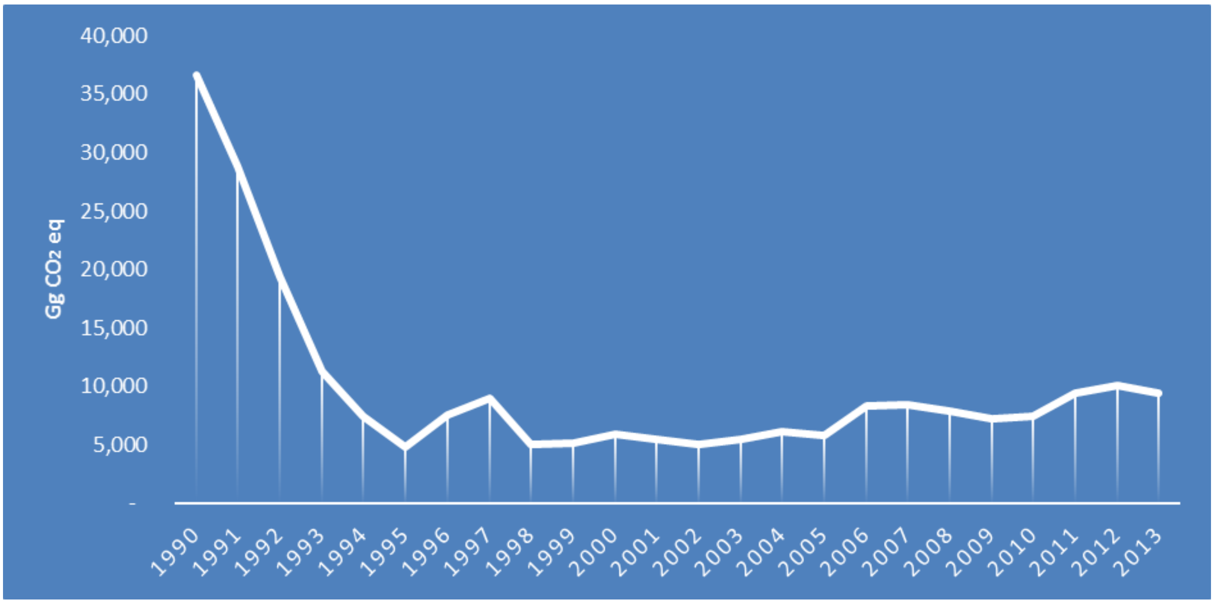


FIG. 2.2. EMISSIONS FROM THE ENERGY SECTOR IN 1990-2013

An increasing trend from 2010-2012 in the growth of emissions across almost all sub source categories of the energy sector is caused by the economic recovery. The rise of emissions can especially be seen in the manufacturing industries, and construction, heat and electricity generation sub-source sectors, where emissions rose respectively by 240% and 76% relative to 2009. Notably, the capacity of hydro resources in Georgia has greatly impacted energy sector emissions and often causes its variation. During 2010-2011, a significant rise of demand for electric energy can be observed (a 10% increase as compared to the previous year). Growth of fuel consumption in other sectors (29% increase of GHG emission during 2009-2012), especially in commercial sector causing the rise of GHG emissions in the energy sector as well. In the transport sector, GHG emissions increased by 27% during 2009-2013, mainly due to the increased quantities of vehicles and gas consumption for transit pipeline operations. Fugitive emissions increased by 15% during 2009-2012, mostly due to the losses in the gas distribution and transmission systems. In 2013, GHG emissions from all energy sub-sectors (except transport sector) decreased by 7% compared to 2012. The reduction of emissions was mainly due to the lower thermal power generation and reduced consumption of fuel in the industry and commercial sectors. As a result of rehabilitation works on gas transmission pipelines, GHG emissions decreased more than 5 times from the source during 2012-2013.

Emissions from the industrial processes sector - Emissions from the industrial process sector cover a 24 year period, from 1990 to 2013. The higher tier methods were used for the following source-categories: Cement Production, Ammonia Production, Iron and Steel Production, Consumption of Halocarbons and Sulphur Hexafluoride in 2010-2013. In order to meet the time series consistency, the next inventory report will address improving methodologies to calculate the entire period.

According to current data, the highest emissions were in 1990, around 5383 Gg of CO2 eq. After the collapse of the country's economy, emissions decreased significantly, reaching its lowest level in 1995. Subsequently, emissions increased again. However, other emission depletions occured in 2001 and 2009-2010, due to the fluctuations in economic processes in Georgia. Over the past four years, emissions had an upwarding trend from 1645 Gg to 3008 Gg of CO2 eq. The increase in emissions from the Industrial Processes were mainly caused by the enlargement of the mineral production processes, which in turn were mostly related to the market recovery.

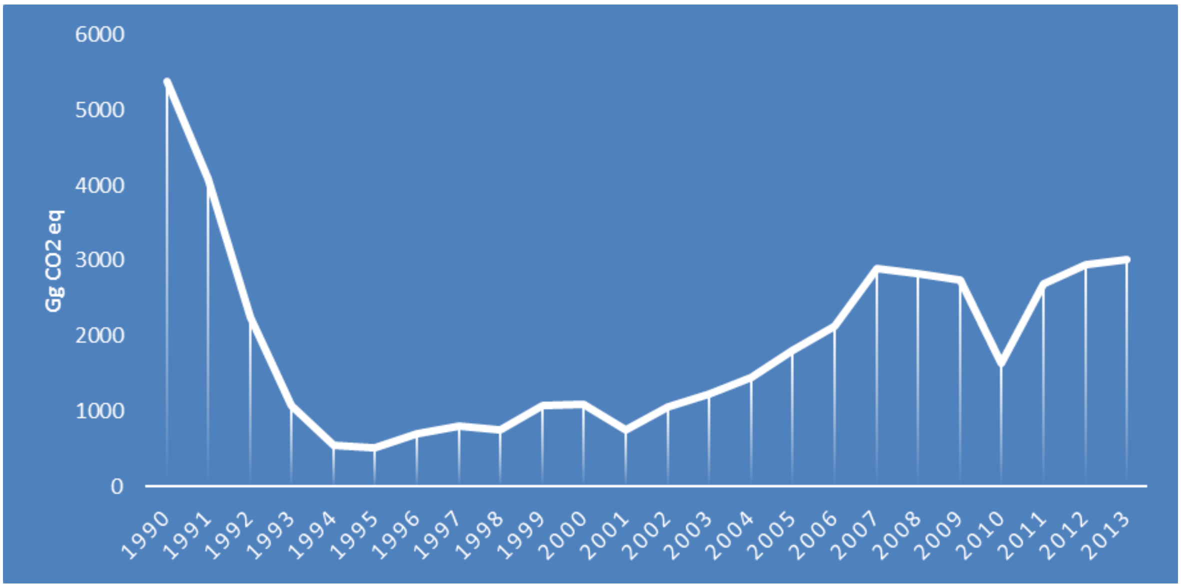


FIG. 2.3. EMISSIONS FROM THE INDUSTRIAL PROCESSES SECTOR IN 1990-2013

Emissions from the Agriculture sector - Since 1990, after collapse of Soviet Union, GHG emissions from the agriculture sector significantly decreased, mainly due a reduced sown area (from 701 thousand ha in 1990 to 453 thousand ha in 1995) and reduced N fertilizer consumption, as well as reduced cattle population (from 1,298 thousand heads in 1990 to 944 thousand heads in 1995). Untill 2006 emissions increased slightly, but a sharp decline of agriculture sector and reduction of related GHG emissions became fixed again. In the past three years, efforts of the Government of Georgia resulted in an increased trend of GHG emissions. Fig. 4.2 shows agriculture sector emissions in 1990-2013.

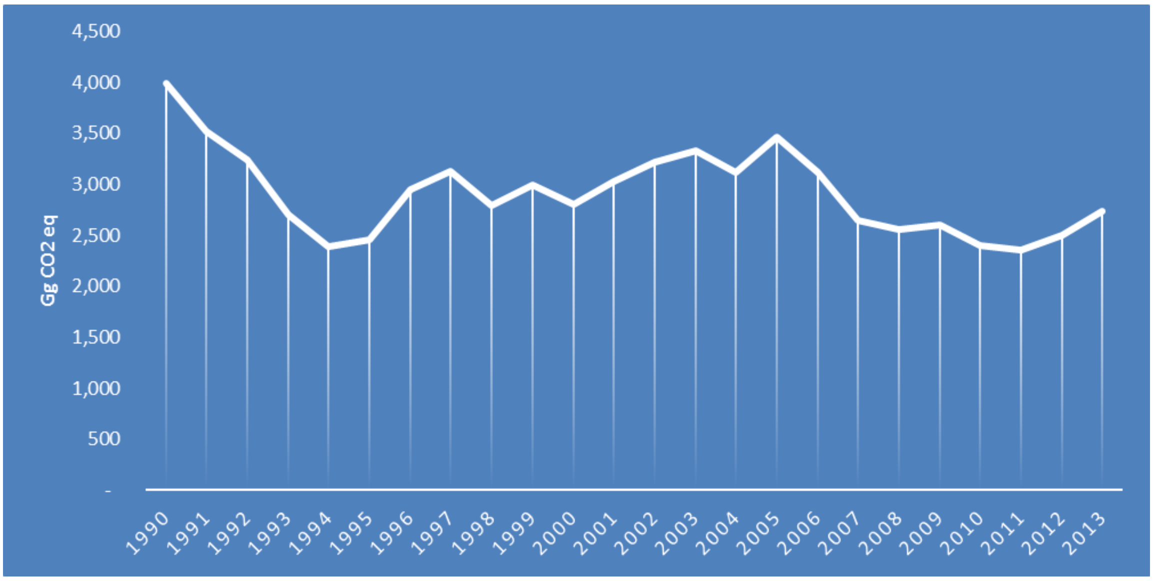


FIG. 2.4. EMISSIONS FROM THE AGRICULTURE SECTOR IN 1990-2013

Emissions from the Waste sector - comprised 8% of the total emissions in 2013, and were 2.6% higher compared to 1990, while 21.5% higher compared to 2000. GHG emissions from the waste sector changed insignificantly during 1990-2013, excluding a sharp decline in 1991 when many industries closed, resulting in reduced wastewater production and methane emissions from SWDS. GHG emissions from residential and commercial wastewater changed mainly due to

changes in population. FIG. 2.5 shows the trend of greenhouse gas emissions from the waste sector during 1990-2013.

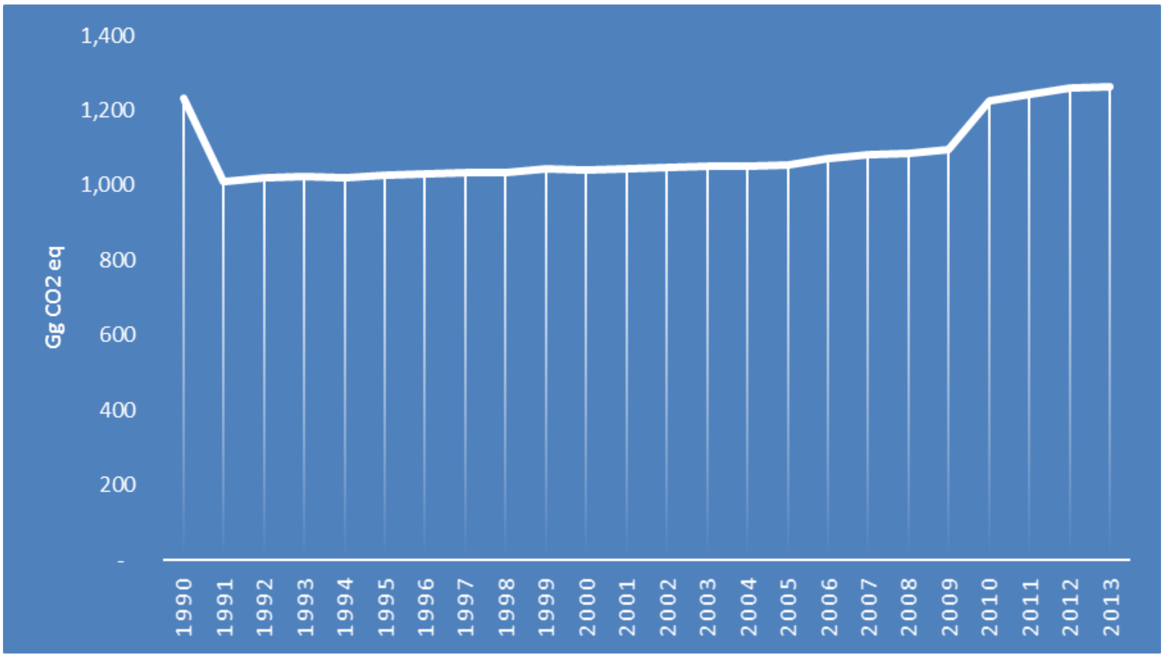


FIG. 2.5. EMISSIONS FROM THE WASTE SECTOR IN 1990-2013

TABLE 2-3 GHGS EMISSION TRENDS BY SECTORS IN 1990-2013 (GG $CO_{2EQ.}$)

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy	36587	28815	19395	11246	7445	4790	7585	9018	5057	5183	5925
Industrial Processes	5383	4084	2245	1068	543	520	703	810	744	1070	1096
Agriculture	3985	3525	3242	2703	2386	2461	2954	3124	2790	2991	2802
Waste	1232	1011	1020	1024	1020	1028	1030	1033	1034	1043	1041
Total	**47,187**	**37,436**	**25,902**	**16,040**	**11,394**	**8,799**	**12,272**	**13,985**	**9,625**	**10,287**	**10,864**

Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Energy	5466	5006	5449	6144	5786	8301	8378	7849	7216	7,458	9,413	10,083	9,386
Industrial Processes	748	1058	1220	1452	1810	2138	2890	2822	2749	1,853	3,013	3,379	3,296
Agriculture	3025	3214	3331	3120	3460	3115	2651	2552	2604	2,403	2,353	2,502	2,732
Waste	1045	1049	1051	1052	1054	1073	1083	1086	1097	1,226	1,243	1,260	1,265
Total	**10,284**	**10,326**	**11,051**	**11,767**	**12,110**	**14,628**	**15,002**	**14,309**	**13,667**	**12,939**	**16,022**	**17,224**	**16,679**

2.3. EMISSION TRENDS BY GREENHOUSE GASES

Table 2.4 shows GHGs emissions by sectors and subsectors for 2013.

TABLE 2-4 GREENHOUSE GAS EMISSIONS BY SECTORS AND SUBSECTORS IN 2013 (Gg)

Greenhouse Gas Sources and Sink Categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)	NOx (Gg)	CO (Gg)	NMVOCs (Gg)	SOx (Gg)
Total national emissions and removals for 2013	**12,017**	**6,595**	**224**	**7**	**46**	**260**	**95**	**2**
1. Energy	**7,283**	**NA**	**98**	**0.12**	**41**	**254**	**41**	**2**
A. Fuel Combustion (sectoral approach)	7,283		7	0.123	41	254	41	2
1. Energy Industries	950		0.02	0.002	3	0.3	0.09	0.001
2. Manufacturing Industries and Construction	1,923		0.17	0.021	6	2	0.3	1
3. Transport	3,071		0.9	0.021	29	155	29	1
4. Other sectors	1,326		6	0.079	4	97	12	0.03
5. Other	12		NE	NE	NE	NE	NE	0.001
B. Fugitive Emissions From Fuels	NA		91		NE	NE	NE	NE
1. Solid Fuels			5		NE	NE	NE	NE
2. Oil and Natural Gas			86		NE	NE	NE	NE
2. Industrial Processes	**2,264**	**NA**	**NA**	**3**	**5**	**2**	**1**	**1**
A. Mineral Products	1,497				NE	0.004	0.15	0.49
B. Chemical Industry	331		NA	3	4.73	1.74	1.04	0.01
C. Metal Production	436		NA	NE	0.01	0.0003	0.01	0.01
D. Other Production	NA		NA	NA	NA	NA	0.02	NA
E. Production of Halocarbons and Sulphur Hexafluoride								
F. Consumption of Halocarbons and Sulphur Hexafluoride								
G. Other	NO		NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA**			**0.00004**			**53.63**	
4. Agriculture			**70.31**	**4.05**	**0.15**	**4**	**NO**	**NA**
A. Enteric Fermentation			64.33					
B. Manure Management			5.63	0.49			NE	
C. Rice Cultivation			NO				NO	
D. Agricultural Soils			NE	3.55			NE	
E. Prescribed Burning of Savannahs			NO	NO	NO	NO	NO	
F. Field Burning of Agricultural Residues			0.35	0.01	0.15	4	NE	
G. Other			NO	NO	NO	NO	NO	
5. Land-use Change and Forestry	**2,470**	**6,595**	**0.014**	**0.0002**	**0.001**	**0.210**	**NA**	**NA**
A. Changes in Forest and Other Woody Biomass Stocks	NE	6,465						

B. Forest and Grassland conversion	NE	NE	0.014	0.0002	0.001	0.21		
C. Abandonment of Managed Lands		NE						
D. CO2 Emissions and Removals from Soil	2,470	129						
E. Other	NO	NO	NO	NO	NO	NO		
6. Waste			**55.20**	**0.34**	**NE**	**NE**	**NE**	**NE**
A. Solid Waste Disposal on Land			41.90		NE		NE	
B. Waste-water Handling			13.30	0.34	NE	NE	NE	
C. Waste Incineration					NE	NE	NE	NE
D. Other			NO	NO	NO	NO	NO	NO
7. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items								
International Bunkers	**267**		NE	NE	NE	NE	NE	NE
Aviation	267		NE	NE	NE	NE	NE	NE
Marine	NE		NE	NE	NE	NE	NE	NE
CO2 Emissions from Biomass	**2,049**							

TABLE 2-5 ANTHROPOGENIC EMISSIONS OF HFCS, PFCS AND SF6 IN 2013

Greenhouse gas source and sink categories	HFCsa,b (Gg)			PFCsa,b (Gg)			SF6a (Gg)
	HFC-23	HFC-134a		CF4	C2F6		
Total national emissions and removals	**NA**	**0.055**		**NA**	**NA**		**NA**
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 f=Fuels							
2. Oil and Natural Gas							
2. Industrial Processes	**NA**	**0.055**		**NA**	**NA**		**NA**
A. Mineral Products							
B. Chemical Industry							
C. Metal Production	NA	NA		NA	NA		NA
D. Other Production							
E. Production of	NA	NA		NA	NA		NA

Greenhouse gas source and sink categories	HFCsa,b (Gg)			PFCsa,b (Gg)			SF6a (Gg)
	HFC-23	HFC-134a		CF4	C2F6		
Halocarbons and Sulphur Hexafluoride							
F. Consumption of Halocarbons and Sulphur Hexafluoride	NA	0.055		NA	NA		NA
G. Other							
3. Solvent and Other Product Use							
4. 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							
5. 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							
6. Waste							
A. Solid Waste Disposal on Land							
B. Waste-water Handling							
C. Waste Incineration							
D. Other							
7. Other (please specify)	**NO**	**NO**		**NO**	**NO**		**NO**
Memo Items							
International Bunkers							
Aviation							
Marine							
CO2 Emissions from Biomass							

Figure 2.6 shows the share of direct greenhouse gas emissions of the country's total (except for the LULUCF Sector). The Figure shows that CO_2 was the highest contributor in 1990 with 81.7%, followed by methane with 12.5% and nitrous oxide, with 5.8%, ranking third. Along with the disintegration of the economy, emissions decreased and for a considerable period (1998-2003)

methane was the leading gas in Georgia's greenhouse gas. From 2004, with economic advancement, CO_2 emissions have been rising. Furthermore, hydrofluorocarbons emissions have risen considerably over the past years, which is related to the rise in the number of refrigerators and conditioners that are charged with hydrofluorocarbons. By 2013, CO_2 accounts for 57.2%, methane – 28.2%, nitrous oxide – 13.3%, while hydrofluorocarbons – 1.2%. The contribution of sulphur hexafluoride (SF_6) emissions is very low.

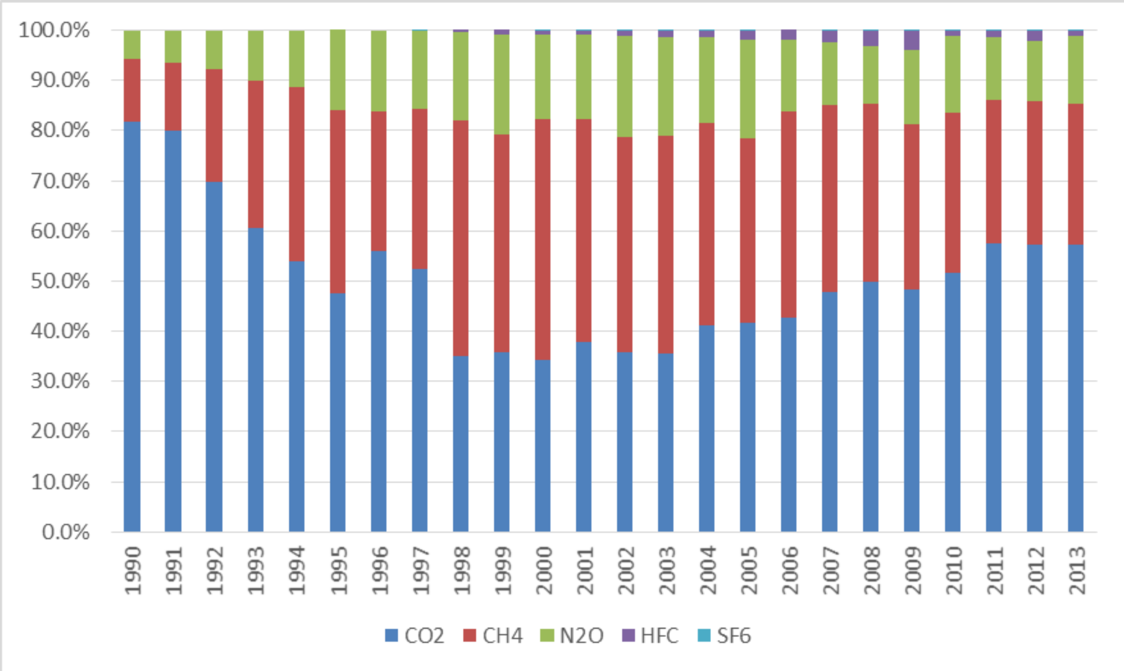


FIG. 2.6. THE SHARE OF DIFFERENT GHGS IN THE TOTAL EMISSIONS FROM THE COUNTRY, 1990-2013

a) Carbon dioxide (CO_2)

In 1990, carbon dioxide emissions comprised 38 543 Gg, and in 2013 – 9 547 Gg. In 2013, carbon dioxide emissions were four times lower relative to 1990, and 2.6 times higher than emissions in 2000. The energy sector is the main source of carbon dioxide emissions, which actually replicates the trends of this sector. Along with the breakup of the Soviet Union, carbon dioxide emissions fell sharply, and until 2002 the level was quite low, while from 2003 it resumed an ascending trend caused by economic growth. Growth of the transport sector and the improvement of living conditions of the population are linked to this as well. In 2008-2010, due to the economic recession, and an increasing share of HPP in power generation carbon dioxide emissions falling sharply, a significant growth of emissions can be observed in 2011, mainly due to the economic advancement which causes a rise in emissions in the energy, as well as in industrial processes sector. One of the reasons for the rise in carbon dioxide emission in 2011 is the high indicator of electricity generation by thermal power plants. Carbon dioxide emission values in 2010-2013 are provided in Fig. 2.7.

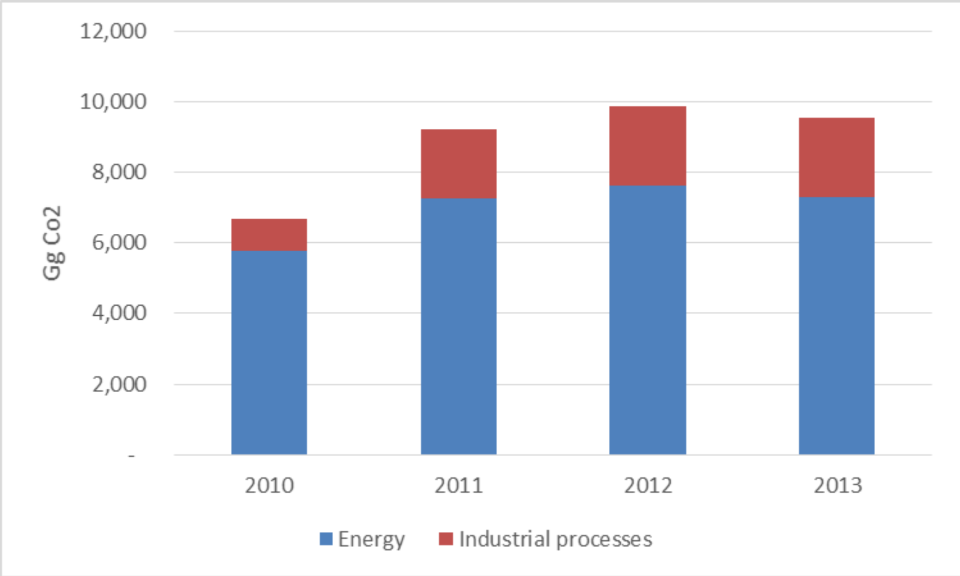


FIG. 2.7. CARBON DIOXIDE EMISSIONS BY SECTORS IN 2010-2013

b) Methane (CH_4)

Methane emissions in 1990 were 5 920 Gg in CO_2 equivalent, while in 2013 it was 4 700 Gg. In 2013, methane emissions fell by 21% compared to 1990, and decreased by 10% compared to 2000. The energy sector is once more the main source of methane emissions, and it accounts for 40% of methane emissions in 2010, and 44% in 2013. The main source for methane emissions in the energy sector is natural gas leakage from gas transmission and distribution sectors, which is characterized by an increasing trend in 2010-2012. This is related to the rising gas transportation due to an increased demand for gas in the power sector, as well as in residential, industry and commercial sectors. The agriculture sector ranks second in terms of methane emissions, and emissions from this sector have increased since 2010. FIG. 2.8 shows methane emissions in 2010-2013 by sectors.

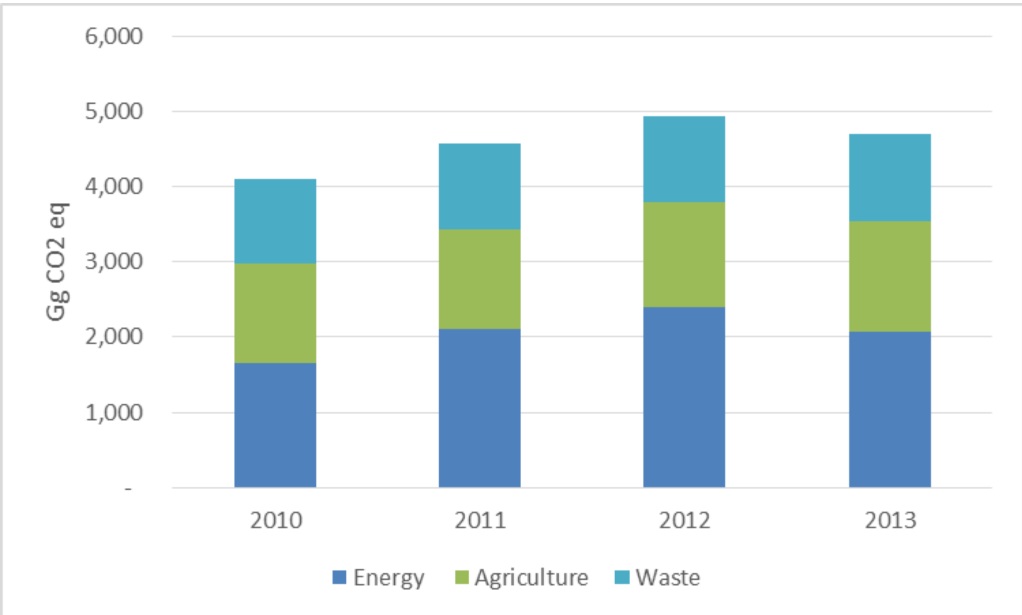


FIG. 2.8. METHANE EMISSIONS BY SECTORS IN 2010-2013

c) Nitrous oxide (N_2O)

Nitrous oxide emissions in 1990 were 2 724 Gg in CO_2 equivalent, while 2 223 Gg in 2013 when nitrous oxide emissions compared to 1990 fell by 18%, and increased by 21% compared to 2000. The main source for nitrous oxide emissions is the agriculture sector which accounts for 56% of nitrous oxide emissions in 2013. The industrial processes sector ranks second (37%). The trends in these two sectors are the main reason of result the variation of the nitrous oxide trend.

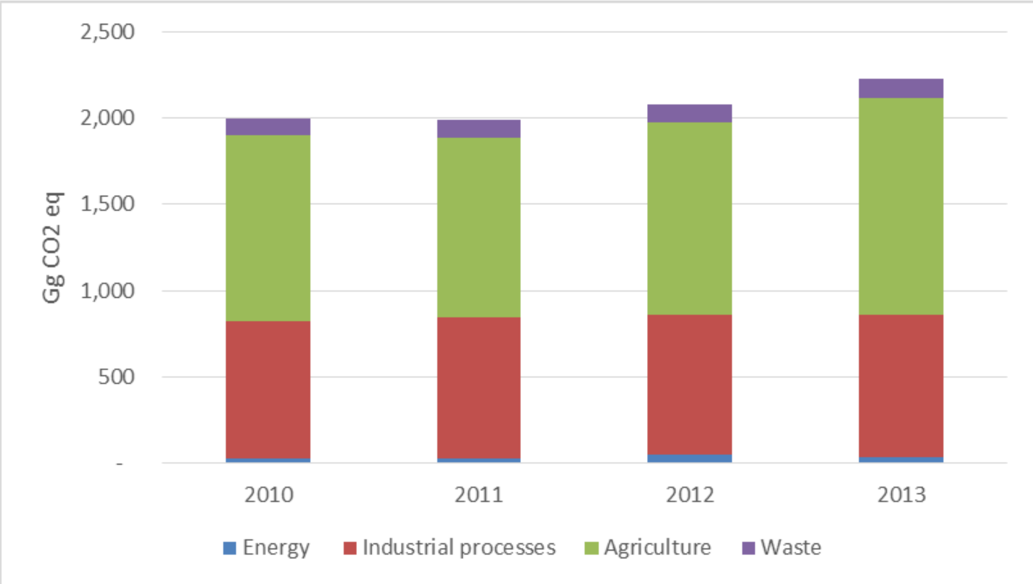


FIG. 2.9. NITROUS OXIDE EMISSIONS BY SECTORS, 2010-2013

d) Hydrofluorocarbons (HFCs) and Sulphur hexafluoride (SF_6).

The counting of HFCs emissions started in 1997. HFCs emission values are shown in Table 2-1, and they are fully originating from the industrial processes sector. In 1997, their emissions in CO_2 equivalent comprised 33 Gg, 90 Gg in 2000, and 208 Gg in 2013. HFCs emissions are characterized by a marked rising trend, due to the accumulation of appliances containing HFCs in the country. The emission from operating industrial refrigeration, and other equipment, accounts for the larger share of emissions.

In Georgia, SF_6, emissions result from the operating process of appliances containing it. In Georgia, at energy facilities, SF_6 is used in grid equipment, namely, its use in various electric switches started from 1997. SF_6 emissions in Georgia are very low and in 2013 their emissions totaled 276 tonnes in CO_2 equivalent.

3. THE ENERGY SECTOR

3.1. SECTOR OVERVIEW AND CALCULATED EMISSIONS

In 2013, greenhouse gas emissions from the energy sector amounted 9,386 thousand tonnes of CO_2 equivalent, which is about 56% of Georgia's total GHG emission (excluding LULUCF). It is considerably lower compared to the contribution of this sector in 1990 (78%). Compared to 1990, the total GHG emissions of the sector decreased four times, while they increased by 58% relative to 2000. A significant fall in GHG emissions in the 1990s is due to the breakup of the Soviet Union and fundamental changes in the economy of the country. However, the national economy started increasing after 2000 and the average annual growth of real GDP amounted to 8.4% before 2008. During 2008-2009, economic growth of Georgia has slowed down due to the Russian-Georgian war. Again, from 2010, the real GDP of the country started increasing by 5.8% on average until 2014[15].

In 2010, hydro generation reached its maximum, while the generation from thermal power plants was the lowest in the past decade. In 2011 emissions from the energy sector increased mainly due to the increased thermal power generation and improvement of the economic situation. Table 3.1 shows the CO_2 equivalent of emissions in the energy sector.

TABLE 3-1 - GREENHOUSE GAS EMISSIONS FROM THE ENERGY SECTOR (GG, CO_2EQ)

Source-Category	1990	1995	2000	2005	2010	2011	2012	2013
1A Fuel combustion	**33,929**	**3,881**	**3,546**	**4,589**	**5,916**	**7,395**	**7,892**	**7,466**
1A1 Energy industries (electricity and heat production)	12,182	1,093	976	784	542	1,220	1,319	951
1A2 Manufacturing industries and construction	10,531	523	415	608	891	1,630	2,004	1,933
1A3 Transport	3,827	1,552	1,120	1,219	2,574	2,537	2,655	3,096
1A4 Other sectors (commercial/ residential/ agriculture/ fishing/ forestry)	7,112	701	1,035	1,978	1,669	1,923	1,914	1,474
1A5 Other (not elsewhere specified)	277	12	0	0	241	86	0	12
1B Fugitive emissions	**2,658**	**909**	**2,381**	**1,196**	**1,542**	**2,018**	**2,191**	**1,920**
1B1. Solid fuels	268	12	2	-	75	99	118	113
1B2. Oil and natural gas	2,390	897	2,379	1,196	1,467	1,919	2,072	1,806
Total from energy sector	**36,587**	**4,791**	**5,927**	**5,786**	**7,458**	**9,413**	**10,083**	**9,386**

As can be seen from the Table, a large share of emissions from the energy sector is due to fuel combustion (80% in 2013) and the remaining 20% is caused by fugitive emissions. Among emission source-categories, the highest growth relative to 2000 was in fugitive emissions from the transformation of solid fuel (2 Gg in 2000, 113 Gg in 2013), which is due to the intensification of coal mining works in recent years. During 2000-2013, GHGs emissions from the industry and transport sectors increased about 4.7 and 2.8 times respectively. In the transport sector, GHG emissions increased due to the growing auto-park and a majoity share of

[15] GEOSTAT – Real Growth of GDP - http://geostat.ge/?action=page&p_id=118&lang=geo

second-hand cars in the park. In Georgia, the number of motor vehicles in 2002-2013 period increased from 319,600 to 906,700[16]. From 2006, the development of energy transit pipelines (South Caucasus Gas Pipeline, Baku-Tbilisi-Erzurum oil Pipeline) though Georgia required additional gas for the pipeline operation. Figure 3.1 shows emission trends in 2000-2013 from the energy sector by various source-categories.

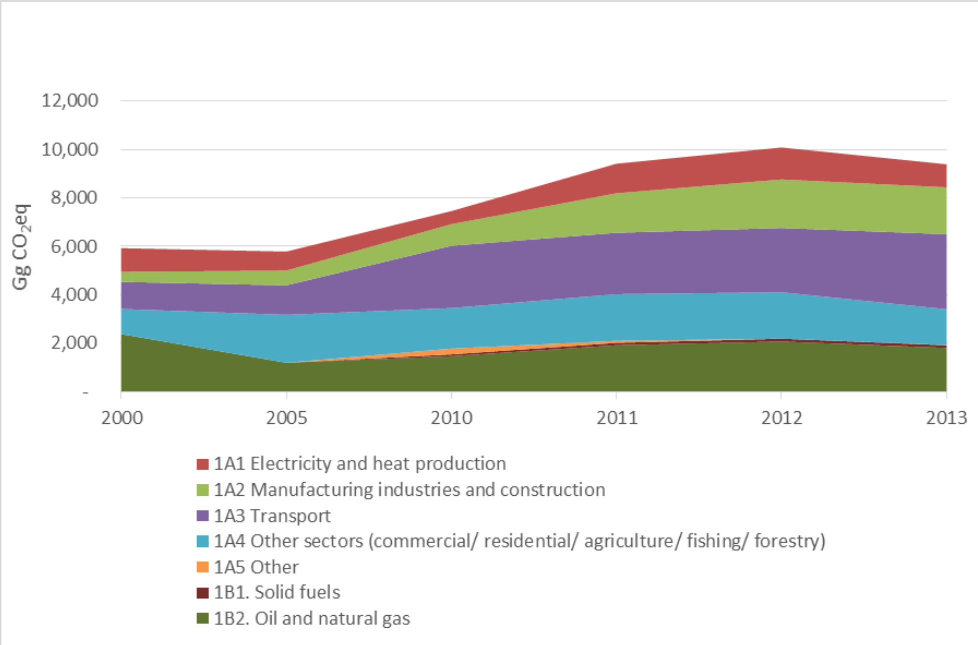


FIGURE 3.1 - TREND OF GREENHOUSE GAS EMISSIONS FROM THE ENERGY SECTOR 2000-2013 (GG CO_2 EQ.)

In 2013 the largest shares, in total, in GHG emission had the following source categories: transport – 33%, manufacturing industries and construction – 21%, gas transmission and distribution subsector – 19% and energy industry (electricity production) – 10%. Figure 3.2 shows the change of the contribution of greenhouse gas emissions in the energy sector in 2000-2013.

[16] GEOSTAT – Annual Report 2014 http://geostat.ge/cms/site_images/_files/yearbook/Yearbook_2014.pdf

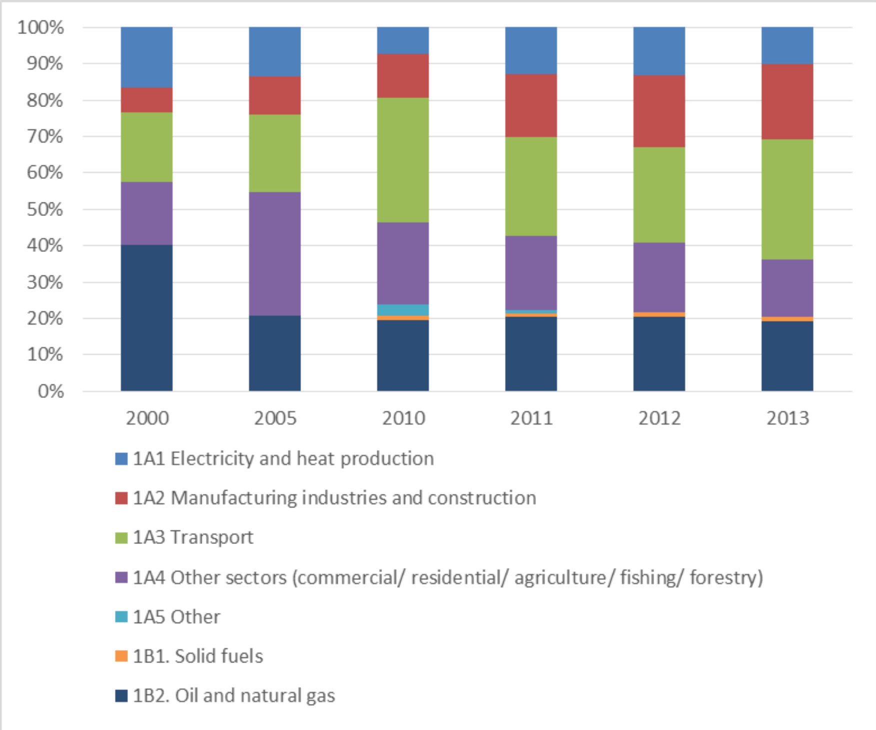


FIGURE 3.2 - CHANGE IN THE SHARE OF EMISSIONS FROM SOURCE-CATEGORIES IN THE ENERGY SECTOR, 2000-2013

Emissions from the electric energy production and transport sectors are characterized by unsteady trends. Fluctuation in the energy industry is due to the changes in consumption of natural gas for power generation, which, in turn, is dependent on the share of hydro power generation. As for the transport sector, changes in shares are mainly due to the switching fuels for cars from gasoline to compressed natural gas (CNG), an increasing number of vehicles in the country, and the development of energy transit pipelines though Georgia.

3.2. FUEL COMBUSTION

3.2.1. DESCRIPTION OF SOURCE-CATEGORY AND CALCULATED EMISSIONS

Emissions of greenhouse gases from the Fuel Combustion source-category totaled 7,466 Gg in CO_2eq in 2013. In that year, carbon dioxide, methane and nitrous oxide accounted for 97%, 2%, and 1% of emissions from fuel combustion source-category respectively. The transport sector has the highest share: 42% in GHGs emissions from the source. The residential sector has the highest contribution in methane and nitrous oxide emissions, due to a high consumption of firewood in this sector. Greenhouse gas emissions from fuel combustion are shown in Table 3.2.

TABLE 3-2 - GREENHOUSE GAS EMISSIONS FROM FUEL COMBUSTION (GG)

Gas	1990	1995	2000	2005	2010	2011	2012	2013
CO_2	**33,775**	**3,857**	**3,177**	**4,015**	**5,775**	**7,269**	**7,637**	**7,283**
CH_4	3	0	15	23	5	5	10	7
$CO_{2eq.}$	**62**	**8**	**305**	**476**	**112**	**96**	**205**	**145**
N_2O	0.30	0.05	0.21	0.32	0.09	0.10	0.17	0.12
$CO_{2eq.}$	**93**	**16**	**64**	**99**	**29**	**30**	**52**	**38**
Total CO2eq.	**33,929**	**3,880**	**3,546**	**4,589**	**5,917**	**7,394**	**7,893**	**7,466**

3.2.2. METHODOLOGY

a) Applied method

Emissions in this 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 in various sectors provided in the country's energy balance.

According to the sectoral approach, carbon dioxide emission is calculated using the formula:

$$\textbf{Carbon dioxide emission}_j\ \textbf{(Gg } CO_2\textbf{) =}$$

$$\sum_i \{[\textbf{Actual consumption of fuel}_{ji}\textbf{(Unit)}$$

$$\textbf{x Calorific value of fuel}_i\textbf{(TJ/Unit)}$$

$$\textbf{x Carbon emission factor}_i\ \textbf{(tC/TJ)/1000}$$

$$\textbf{-Carbon stored}_i\textbf{] x Fraction of carbon oxidized}_i\textbf{\} x 44/12}$$

Where the lower index *j* stands for the sector, and the lower index *i* refers to the type of fuel.

Not all fuel supplied to an economy is burned for heat energy. Some is used as a feedstock for manufacture 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 use by activities using the fuel as raw material. Carbon stored in products is calculated using the formula:

$$\textbf{Carbon stored (Gg C) = Non-energy use (}10^3\textbf{t)}$$

$$\textbf{x Calorific value of fuel (TJ/}10^3\textbf{t)}$$

$$\textbf{x Carbon emission factor (t C/TJ)}$$

$$\textbf{x Fraction of carbon stored x } 10^{-3}$$

For other gases emissions under the sectoral approach are calculated using the formula:

$$\textbf{Other GHGs emission}_j\ \textbf{(Gg gas) =}$$

$$\sum_i [\textbf{Actual consumption of fuel}_{ji}\ \textbf{(Unit)}$$

$$\textbf{x Calorific value of fuel}_i\ \textbf{(TJ/Unit)}$$

$$\textbf{x Gas emission factor}_{ji}\ \textbf{(t Gas/TJ)/1000]}$$

Where the lower index *j* stands for the type of gas, and lower index *i* refers to the type of fuel.

b) Activity data

Generally, in the energy sector the national energy balance is the basis for the assessment of greenhouse gas emissions in the course of fuel combustion. In energy balance production of fuel, its import, export, changes in stocks, and consumption, is provided in physical units (tonnes or m^3) or in energy units (terajoules or kilo tonnes 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[17] for 2013, counting from 2000. Improving the quality of data is still continuing, as GEOSTAT has been working on the next energy balance for the year 2014. Some corrections have already been made in the 2013 energy balance. Meanwhile, there are no official energy balances available for 2010-2012, and activity data has been taken from various sources.

The following data was provided from different sources:

- Updated information about the annual production, export and import of oil products and solid fuels for 2010-2013, as well as the first official energy balance for 2013 wereprovided by the National Statistics Office of Georgia (GEOSTAT)[18];
- Natural gas balances for 2010-2013, jet kerosene and firewood supply, and consumption data were obtained from the Ministry of Energy, Georgia (MoE)[19];
- Information on the natural gas transit were provided by the Georgian Oil and Gas Corporation (GOGC)[20];
- Electricity balances for 2010-2013 years were obtained from the Electricity Market Operator (ESCO)[21];
- Natural gas distribution losses for 2012-2013 were provided by the Georgian National Energy and Water Supply Regulatory Commission (GNERC)[22];
- Data for natural gas consumption in operations of energy transit pipelines wereprovided by the British Petroleum Georgia[23] (see annex D).

Based on the data, aggregated energy balances were prepared for 2010-2013 (provided in Annex D). Data provided by BP-Georgia has not been reflected in the energy balances, asthe country has neither the right, nor the obligation to intervene in the operations of SCP and BTC transit. However, the data has been used for GHG emission calculation in the transport sector.

c) 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, than when expressed on a 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. Standard and country specific values of carbon emission factors and conversion factors were obtained from the IPCC 1996 guidelines and the GEOSTAT energy balance 2013 document (Table 3.3).

[17] GEOSTAT - Energy Statistics http://geostat.ge/index.php?action=page&p_id=1895&lang=eng
[18] www.geostat.ge
[19] www.energy.gov.ge
[20] www.gogc.ge
[21] www.esco.ge
[22] www.gnerc.org
[23] www.bpgeorgia.ge

TABLE 3-3 - CONVERSION FACTORS AND CARBON EMISSION FACTORS FOR VARIOUS TYPES OF FUEL[24]

Fuel type	Unit	Net Calorific Values (TJ/Unit)	Carbon Emission Factor (t C/ TJ)
Crude Oil	1000 t	42.08	20
Gasoline (Auto and Aviation)	1000 t	44.8	18.9
Jet Kerosene	1000 t	44.59	19.5
Other Kerosene	1000 t	44.75	19.6
Gas/Diesel Oil	1000 t	43.33	20.2
Residual Fuel Oil (Mazut)	1000 t	40.19	21.1
LPG	1000 t	45	17.2
Naphtha	1000 t	45.01	20
Bitumen	1000 t	40.19	22
Lubricants	1000 t	40.19	20
Other Oil Products	1000 t	40.19	20
Anthracite	1000 t	29.31	26.8
Hard Coal	1000 t	18.58	25.8
Lignite	1000 t	17.40	27.6
Sub-Bituminous Coal	1000 t	14.65	26.2
Other-Bituminous Coal	1000 t	25	25.8
Coking Coal	1000 t	28	25.8
Coke Oven/Gas Coke	1000 t	29.31	29.5
Natural Gas (NG)	1 000 000 m^3	33.66	15.3
Fuel Wood	1000 m^3	7.5	29.9
Petroleum Coke	1000 t	31	27.5

When energy is consumed, not all of the carbon in the fuel oxidizes to CO_2. Incomplete oxidation occurs due to inefficiencies in the combustion process, which leaves some of the carbon unburned or partly oxidized as soot or ash. In calculations, it is implied that carbon that remains unoxidized is stored for an indefinite time. The standard values of the fraction of oxidized carbon used in the 2010-2013 inventory recommended by IPCC are provided in Table 3.4.

TABLE 3-4 - THE FRACTION OF OXIDIZED CARBON FOR VARIOUS FUELS

Fuel	The fraction of carbon oxidized
Coal	0.980
Oil and Oil Products	0.990
Natural Gas	0.995

[24] Country specific Net Calorific Values for LPG, Anthracite, Lignite, Other Bituminous Coal, Coke Oven, Coking Coal and Natural Gas have been obtained from the energy balance 2013 document (GEOSTAT).

Some of the fuel supplied to an economy is used as a raw material (or feedstock) for manufacture of products such as plastics, fertilizer, or in a non-energy use. The amounts of carbon stored for long periods are called stored carbon and should be deducted from the carbon emissions calculation. Standard values of carbon stored in various products, according to IPCC, are provided in Table 3.5.

TABLE 3-5 - STANDARD VALUES OF CARBON STORED IN THE PRODUCT

Fuel	Fraction of stored carbon
Bitumen	1.00
Coal Oils and Tars	0.75
Gas/Diesel Oil as a Feedstock	0.50
LPG as a Feedstock	0.80
Lubricants	0.50
Naphtha as a Feedstock	0.80
Natural Gas as a Feedstock	0.33

Emissions of other (than carbon dioxide) greenhouse gases, depends on the type of fuel, as well as the sector, used technologies, and the modes of operation. The data is provided in relevant subchapters of the specific source-categories.

In the energy sector, emissions of indirect greenhouse gases were calculated as well, and standard values of emission factors were taken from the IPCC methodology for the inventory 2010-2013.

Recalculations in GHGs emission inventories for 2010-2011 are mainly based on updated information on coal and natural gas supply, and consumption and country specific net calorific values for some fuels (LPG, Anthracite, Lignite, Other Bituminous Coal, Coke Oven, Coking Coal and Natural Gas), which were provided by GEOSTAT.

3.2.3. COMPARISON BETWEEN THE RESULTS OF SECTORAL AND REFERENCE APPROACHES

According to the IPCC Guidelines, CO_2 emissions from fuel combustion should be estimated using the IPCC Reference Approach as the primary means of preparing the inventory, or as a verification stage following the preparation of an inventory using sectoral approach. The Reference Approach is a simple procedure which demands relatively little data. 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 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 formula:

$$\begin{gathered}\textbf{Carbon dioxide emission (Gg CO}_2\textbf{) =}\\ \sum_i \{[\textbf{Apparent Consumption of fuel}_i \textbf{ (Units)}\\ \textbf{x Calorific value of fuel}_i \textbf{ (TJ/Unit)}\\ \textbf{x Carbon emission factor}_i \textbf{ (t C/TJ) /1000}\\ \textbf{- Stored carbon}_i]\\ \textbf{x Fraction of carbon oxidized}_i\}\\ \textbf{x 44/12,}\end{gathered}$$

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

Carbon stored in the products is calculated using the formula:

Carbon stored (Gg C)= Non-energy use (10^3t)
x Calorific value of fuel (TJ/10^3t)
x Carbon emission factor (t C/TJ)
x Fraction of carbon stored x 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 fuel combustion is not always complete, but also because 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 a national economy in fuel, it is either saved in some way or it must be released to the atmosphere. In order 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 IPCC methodology determines for the countries included in Annex 1, that the difference between carbon dioxide emissions calculated using the Reference approach and Sectoral approach, should not be more than 2%, otherwise the reason for the difference should be explained.

Table 3.6 Shows carbon dioxide emissions in 2010-2013, calculated using these two approaches for different types of fuel, followed by the explanation of differences.

TABLE 3-6 - COMPARISON OF CARBON DIOXIDE EMISSIONS CALCULATED USING THE REFERENCE AND SECTORAL APPROACHES

Fuel type	Year	2010	2011	2012	2013
Liquid fuel	Reference approach, Gg	2,939	2,925	2,885	2,718
	Sectoral approach, Gg	2,923	2,905	2,860	2,696
	Difference,%	0.6%	0.7%	0.9%	0.8%
Solid fuel	Reference approach, Gg	893	1,185	1,302	1,328
	Sectoral approach, Gg	893	1,185	1,302	1,328
	Difference,%	0.0%	0.0%	0.0%	0.0%
Gas fuel	Reference approach, Gg	2,309	3,603	3,929	3,687

Fuel type	Year	2010	2011	2012	2013
	Sectoral approach, Gg	1,960	3,178	3,474	3,259
	Difference,%	17.8%	13.4%	13.1%	13.1%
Total	Reference approach, Gg	6,141	7,713	8,115	7,733
	Sectoral approach, Gg	5,775	7,269	7,637	7,283
	Difference,%	6.3%	6.1%	6.3%	6.2%

The differences in emissions provided in Table 3.6 are due to the fact that the use of fuel for non-energy purposes has been excluded from the data of the consumption of fuel, under the sectoral approach, while under the Reference approach just a fraction of this amount is determined as stored in the products (33% for natural gas, 50% for lubricant oils). Specifically, in case of gaseous fuels, this difference is due to 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. As for the losses of transportation and distribution, they are quite high in Georgia (see the section 3.3.3).

3.2.4. INTERNATIONAL BUNKER FUEL

The IPCC methodology subtracts the quantities delivered to and consumed by ships or aircraft for international transport from the fuel supply to the country. In this manner, the CO_2 emissions arising from the use of international bunkers are not included in the national total. The 2010-2013 Inventory provides emissions only from the International Aviation Bunker fuel. Information about the consumption of jet kerosene was provided by the Ministry of Energy, Georgia. Information about marine bunker fuel is not available.

TABLE 3-7 - EMISSIONS OF FUEL CONSUMED BY INTERNATIONAL AVIATION BUNKERS

Year	Jet kerosene consumption, Gg	Carbon dioxide emission, Gg
2010	38.72	122.21
2011	35.00	110.47
2012	68.25	215.42
2013	84.61	267.05

3.2.5.THE CONSUMPTION OF FUEL AS A FEEDSTOCK AND FOR NON-ENERGY PURPOSES

Not all fuel supplied to an economy is burned for heat energy. Some 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 candles production), without oxidation (emissions) of carbon. This is called 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 Table 3.8.

TABLE 3-8 - THE CONSUMPTION OF FOSSIL FUEL FOR NON-ENERGY PURPOSES

Year	Lubricants (Gg)	Bitumen (Gg)	Natural gas, mln.m3
2010	10.16	93.20	116.51
2011	13.69	59.81	126.33
2012	16.94	102.05	132.75
2013	15.02	79.08	141.17

3.2.6. ELECTRICITY AND HEAT PRODUCTION

3.2.6.1. DESCRIPTION OF SOURCE CATEGORY AND CALCULATED EMISSIONS

In Georgia, electric energy is produced by hydropower plants and gas thermal power plants. Georgia is a country rich with hydro resources and the largest share of power generation comes from hydropower plants. For 2014, the country has 64 HPPs and 4 TPPs with installed capacities of 2,791 MW and 680 MW respectively. The electric energy production by hydro and thermal power plants for 2010-2013 years are provided in Table 3.9.

TABLE 3-9 - ELECTRIC ENERGY PRODUCTION

Year	Thermal Power Plants (GWh)	Hydro Power Plants (GWh)	Total
2010	683	9,375	10,058
2011	2,212	7,892	10,105
2012	2,477	7,221	9,698
2013	1,788	8,271	10,059

As can be seen from the Table, domestic power production increased in 2011 compared to 2010 and decreased in 2012 due to the reduction in hydro power generation. The largest share of hydro power production – 93% in total power generation, can be noticed in 2010 due to the high level of precipitation. It should also be mentioned that in 2010, increased demand was met owing to hydro plants, but in 2011 HPPs did not produce the same amount of energy as in prior years, accompanied by further increase of demand. The deficit derived in that year was covered by means of increased production by thermal power plants. In 2011 and 2012, with increasing power consumption, hydropower generation decreased and generation from thermal power plants increased. During 2010-2013, the average annual electricity consumption growth rate was 4.7%[25]. In 2013, four new hydro power plants with 46 MW installed capacity (250 GWh annual generation) were completed.

As for heat production, during the Soviet period, till 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, the majority of the population uses firewood and

[25] ESCO – power balance http://esco.ge/index.php?article_id=8&clang=0

natural gas for heating. Emissions from the consumption of these fuels are reflected in the residential sub-category.

The consumption of gas by thermal power plants is the main cause of emissions from the electric energy production source-category.

TABLE 3-10 - GHGS EMISSIONS FROM THE ELECTRIC ENERGY AND HEAT PRODUCTION SOURCE-CATEGORY (GG)

Gas	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
CO_2	**12,165**	**975**	**783**	**1,349**	**924**	**795**	**749**	**541**	**1,219**	**1,318**	**950**
CH_4	0.22	0.02	0.02	0.03	0.02	0.02	0.02	0.01	0.02	0.02	0.02
$CO_{2eq.}$	**4.62**	**0.39**	**0.39**	**0.55**	**0.38**	**0.33**	**0.38**	**0.21**	**0.42**	**0.42**	**0.36**
N_2O	0.040	0.003	0.003	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002
$CO_{2eq.}$	**12.4**	**0.62**	**0.82**	**0.92**	**0.65**	**0.57**	**0.82**	**0.62**	**0.74**	**0.74**	**0.53**
Total in $CO_{2eq.}$	**12,182**	**976**	**784**	**1,350**	**925**	**796**	**750**	**542**	**1,220**	**1,319**	**951**

3.2.6.2. METHODOLOGY

a) Used method

Emissions have been calculated using the IPCC Tier 1 Sectoral Approach explained in Paragraph 1.2.2.a.

b) Activity data

Data was taken from the energy balances (See Annex D), which were compiled based on the data sources described in Paragraph 3.2.2.b.

c) Conversion factors

Country specific net calorific values were used to convert the amount of consumed fuel from physical units into energy units. Factors from the IPCC 1996 standard values of carbon emission were used. These factors are provided in Table 3.3. Methane and nitrous oxide emission factors are provided in Table 3.11.

TABLE 3-11 - METHANE AND NITROUS OXIDE EMISSION FACTORS FOR POWER AND HEAT PRODUCTION SOURCE CATEGORY (KG/TJ)

GHGs	Natural gas	Diesel
CH_4	1.0	3.0
N_2O	0.1	0.6

Calculated emissions are provided in Table 3.10.

3.2.7. MANUFACTURING INDUSTRIES AND CONSTRUCTION

3.2.7.1. DESCRIPTION OF THE SOURCE-CATEGORY AND CALCULATED EMISSIONS

Manufacturing industries and the construction sub-sector, comprise emissions caused 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.

The heavy manufacturing industry in Georgia is one of the most important sectors in terms of value added, exports and employment. After the break-up of the Soviet Union, almost 1/3 of Georgian factories ceased production. But from 1995 the political stabilization and development of new industrial contacts has led to a relative stabilization of main industrial indicators and a positive growth of GDP. During 2010-2013, the annual growth rate of Industrial production and construction amounted to 13% on average, and its share in total GDP reached 16% in 2013[26].

Manganeze alloys is Georgia's largest export goods. The main Ferroalloys producer in Georgia, Zestaponi ferroalloy plant, is the largest ferroalloy plant in Caucasus and produces mainly silicomanganese. A large metallurgical plant located in Rustavi began steel production in 1950. The plant produced coke, sinter, pig iron, steel, rolled items, and hot-rolled and cold-drawn steel pipes. In 1990-ies, the production of steel and iron significantly reduced, and in 2000 stopped completely. In 2007, the plant recommenced steel production, but only based on scrap steel.

The Rustavi fertilizer plant "Azoti", produces ammonia and nitric acid (as basic chemicals to produce nitrogenous fertilizers: ammonium nitrate and ammonium sulfate).

In 2013, cement production reached 1.6 million tonnes. The two largest cement plants are Kaspi Cement and Rustavi Cement. There are also several small and medium size cement plants using clinker produced by Heidelberg Cement.

During 2010-2013, primarily coal products and natural gas were used with small amounts of oil products (gasoline, diesel oil and residual fuel oil) in this sector. Below, in Table 3.12, GHGs emissions from the manufacturing industries and construction are provided. GHGs emissions increased about 2.17 times from 2010 to 2013 from the source category.

TABLE 3-12 - GHGS EMISSIONS FROM THE MANUFACTURING INDUSTRIES AND CONSTRUCTION SOURCE– CATEGORY (GG)

Gas	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
CO_2	**10,481**	**519**	**413**	**607**	**546**	**719**	**653**	**587**	**887**	**1,622**	**1,994**	**1,923**
CH_4	0.72	0.04	0.03	0.04	0.05	0.06	0.05	0.04	0.08	0.15	0.18	0.17
$CO_{2eq.}$	**15.12**	**0.84**	**0.58**	**0.93**	**0.96**	**1.31**	**1.12**	**0.92**	**1.76**	**3.19**	**3.75**	**3.63**
N_2O	0.11	0.01	0	0	0	0	0	0	0.01	0.02	0.02	0.02
$CO_{2eq.}$	**34.1**	**3.1**	**0.77**	**0**	**0.4**	**0.47**	**0.53**	**0.6**	**2.64**	**5.23**	**6.44**	**6.49**
Total in CO_2eq.	**10,531**	**523**	**415**	**608**	**547**	**721**	**655**	**589**	**891**	**1,630**	**2,004**	**1,933**

3.2.7.2. METHODOLOGY

a) Used method

Emissions were calculated using the IPCC Tier 1 sectoral approach.

b) Activity data

Data was taken from the energy balances (See Annex D), which were compiled based on the data sources described in Paragraph 3.2.2.b.

[26] GESOTAT – GDP in current prices 2013.

c) Emission factors

Country specific net calorific values were used to convert the amount of consumed fuel from physical units into energy units. Factors from the IPCC 1996 standard values of carbon emission were used. These factors are provided in Table 3.3. Methane and nitrous oxide emission factors are provided in Table 3.13.

TABLE 3-13 - METHANE AND NITROUS OXIDE EMISSION FACTORS FOR SOURCE-CATEGORY MANUFACTURING INDUSTRIES AND CONSTRUCTION (KG/TJ)

GHGs	Coal	Natural gas (NG)	Oil products
CH_4	10.0	5.0	2.0
N_2O	1.4	0.1	0.5

3.2.8. TRANSPORT

3.2.8.1. 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 routs to Russia, Turkey and (over the Black Sea) to Europe. Georgia's oil and gas pipelines, Black Sea ports, developed railway system, and airports with direct air services to 17 locations are also playing an increasingly important role in linking East and West.

The transport sector in Georgia, like in the majority of the world's countries, is one of the most significant emitters of greenhouse gases, and therefore major attention is paid to the inventory of emissions from this sector and 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 motor vehicles in this vehicles fleet, and the growth of transit. Since Georgia is a transit country, along with the growth of local vehicles fleet, the number of transit trucks consuming fuel purchased in Georgia is increasing as well. Annual growth of local and transit transport causes the increase of not only carbon dioxide and other greenhouse gases, but also the increase of local pollutants which seriously effect human health. Energy transit pipelines (Baku-Tbilisi-Ceyhan oil and South Caucasus Gas pipelines) go through Georgia as well. Service company British Petroleum uses natural gas at the substations to operate the pipelines.

Under the transport sector, Georgia's GHGs Inventory reviews 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. As can be seen from the table, like other source-categories of fuel combustion, carbon dioxide is a dominant greenhouse gas in this case as well (99.2% of emissions).

TABLE 3-14 - GHGS EMISSIONS FROM THE TRANSPORT SOURCE-CATEGORY (GG)

Gas	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
CO_2	**3,793**	**1,537**	**1,112**	**1,212**	**1,747**	**2,022**	**2,168**	**2,423**	**2,558**	**2,521**	**2,639**	**3,071**
CH_4	0.59	0.28	0.26	0.29	0.37	0.19	0.47	0.5	0.46	0.45	0.47	0.86
CO_{2eq}.	**12.39**	**5.88**	**5.5**	**6.18**	**7.78**	**3.99**	**9.82**	**10.56**	**9.66**	**9.45**	**9.87**	**18.06**
N_2O	0.07	0.03	0.01	0	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
CO_{2eq}.	**21.7**	**9.3**	**3.07**	**0.94**	**4.45**	**5.1**	**5.52**	**6.32**	**6.20**	**6.20**	**6.20**	**6.20**
Total in CO_{2eq}.	**3,827**	**1,552**	**1,120**	**1,219**	**1,759**	**2,031**	**2,183**	**2,440**	**2,574**	**2,537**	**2,655**	**3,096**

Greenhouse gases emissions by subcategories in 2010-2013 are provided by subsectors. The dominant subsector is road transport (93.4% of emissions in 2013). As railway transport is fully electrified effectively in Georgia, it is insignificant in terms of emissions.

TABLE 3-15 - GHGS EMISSIONS FROM TRANSPORT SUB-CATEGORIES (GG)

Source/gas	2010	2011	2012	2013
1A3a Civil aviation total in $CO_{2eq.}$	**0.00**	**57.44**	**1.83**	**2.27**
CO_2	**0**	**56.81**	**1.8**	**2.24**
CH_4	0	0.0004	0.00001	0.00002
$CO_{2eq.}$	**0**	**0.0084**	**0.0003**	**0.0003**
N_2O	0	0.002	0.0001	0.0001
$CO_{2eq.}$	**0**	**0.62**	**0.03**	**0.03**
1A3b Road transportation total in $CO_{2eq.}$	**2,375**	**2,277**	**2,438**	**2,892**
CO_2	**2,358.73**	**2,261.63**	**2,422.20**	**2,867.45**
CH_4	0.46	0.45	0.47	0.86
$CO_{2eq.}$	**9.66**	**9.45**	**9.87**	**18.06**
N_2O	0.020	0.019	0.020	0.021
$CO_{2eq.}$	**6.20**	**5.89**	**6.20**	**6.51**
1A3c Railways total in $CO_{2eq.}$	**17**	**0**	**29**	**29**
CO_2	**16.99**	**0.00**	**28.50**	**28.66**
CH_4	0.0012	0	0.0019	0.002
$CO_{2eq.}$	**0.03**	**0.00**	**0.04**	**0.04**
N_2O	0.00014	0	0.0002	0.0002
$CO_{2eq.}$	**0.04**	**0.00**	**0.06**	**0.06**
1A3d National Navigation total in $CO_{2eq.}$	**NE**	**NE**	**4**	**4**
CO_2	**NE**	**NE**	**4.13**	**4.04**
CH_4	**NE**	**NE**	**0.0003**	**0.0003**
$CO_{2eq.}$	**NE**	**NE**	**0.01**	**0.01**
N_2O	**NE**	**NE**	**0.00003**	**0.00003**
$CO_{2eq.}$	**NE**	**NE**	**0.01**	**0.01**

Source/gas	2010	2011	2012	2013
1A2e Other transportation (pipelines, off road) total in CO2eq.	**182**	**203**	**182**	**169**
CO_2	182	203	182	169
CH_4	0	0	0	0
$CO_{2eq.}$	0	0	0	0
N_2O	0	0	0	0
$CO_{2eq.}$	0	0	0	0
Total from sector in $CO_{2eq.}$	**2,574**	**2,537**	**2,655**	**3,096**

3.2.8.2. METHODOLOGY

a) Used 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, and not on the type of transport that has combusted. Methane and nitrous oxide emissions are dependent on the motor vehicle type, catalyzer type and the mode of operation, and for calculating their emissions it is recommended to use higher-tier methods. Such detailed information does not exist in Georgia, therefore, the Tier 1 sectoral approach was used for all greenhouse gases.

b) Activity data

Data was taken from the energy balances (See Annex D), which were compiled based on the data sources described in Paragraph 3.2.2.b. Information on gas consumption for pipeline operations were provided by British Petroleum Georgia (see Annex D).

c) Emission factors

Country specific net calorific values were used to convert the amount of consumed fuel from physical units into energy units. Factors from the IPCC 1996 standard values of carbon emission were used. These factors are provided in Table 3.3. Methane and nitrous oxide emission factors are provided in Table 3.16 below.

TABLE 3-16 - METHANE AND NITROUS OXIDE EMISSION FACTORS FOR TRANSPORT SOURCE-CATEGORY (KG/TJ)

GHGs	Petrol	Diesel	Natural Gas	Aviation kerosene
CH_4	20.0	5.0	50.0	0.5
N_2O	0.6	0.6	0.1	2.0

3.2.9. OTHER SECTORS – COMMERCIAL / RESIDENTIAL / AGRICULTURE / FISHING / FORESTRY

3.2.9.1. SOURCE CATEGORY DESCRIPTION AND CALCULATED EMISSIONS

Emissions in this source-category comprise of 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 (8% in 2013) and nitrous oxide (2% in 2013) are high, compared to other source categories; this is due to firewood consumption in the residential sector.

TABLE 3-17 - GREENHOUSE GASES EMISSIONS FROM THE COMMERCIAL/RESIDENTIAL/AGRICULTURE/ FISHING/FORESTRY SOURCE-CATEGORIES (GG)

Gas	1990	1995	2000	2005	2010	2011	2012	2013
CO_2	**7,077**	**696**	**677**	**1,413**	**1,549**	**1,822**	**1,686**	**1,326**
CH_4	0.49	0.05	14.20	22.30	4.78	3.93	9.09	5.85
$CO_{2eq.}$	**10**	**1**	**298**	**468**	**100**	**83**	**191**	**123**
N_2O	0.08	0.01	0.19	0.31	0.06	0.06	0.12	0.08
$CO_{2eq.}$	**25**	**3**	**59**	**97**	**20**	**19**	**37**	**25**
Total in $CO_{2eq.}$	**7,112**	**701**	**1,035**	**1,978**	**1,669**	**1,923**	**1,914**	**1,474**

Greenhouse gases emissions by subcategories in 2010-2013 are provided in Table 3.18. The residential sector is a dominant subsector (80.4% in 2013), while GHGs emissions from commercial and agricultural sub-sectors amounted to 17.4% and 2.2% respectively. Commercial and residential sectors are characterized by an increasing trend during 2010-2012 and decreasing trend in 2013, while the agricultural sector emissions decreased in 2012-2013.

TABLE 3-18 - GHGS EMISSIONS FROM COMMERCIAL/RESIDENTIAL/AGRICULTURE/FISHING/ FORESTRY SOURCE-CATEGORIES, BY SUB-CATEGORIES (GG)

Source|Gas	2010	2011	2012	2013
1A4a Commercial total in $CO_{2eq.}$	216.54	356.81	544.78	256.65
CO_2	206.25	345.18	524.56	253.59
CH_4	0.41	0.46	0.80	0.12
$CO_{2eq.}$	8.56	9.66	16.80	2.52
N_2O	0.01	0.01	0.01	0.00
$CO_{2eq.}$	1.72	1.97	3.42	0.54
1A4b Residential total in $CO_{2eq.}$	1,149.64	1,239.53	1,295.10	1,186.32
CO_2	1,047.72	1,152.38	1,087.12	1,041.19
CH_4	4.03	3.44	8.28	5.73
$CO_{2eq.}$	84.57	72.24	173.88	120.33
N_2O	0.06	0.05	0.11	0.08
$CO_{2eq.}$	17.35	14.91	34.10	24.80

1A4c Agriculture/ Forestry/ Fishing total in $CO_{2eq.}$	303.05	325.09	74.49	31.80
CO_2	294.89	323.99	74.09	31.67
CH_4	0.35	0.02	0.01	0.00
$CO_{2eq.}$	7.35	0.42	0.21	0.06
N_2O	0.00	0.00	0.00	0.00
$CO_{2eq.}$	0.81	0.68	0.19	0.06
Total from sector in $CO_{2eq.}$	1,669.23	1,921.43	1,914.36	1,474.76

3.2.9.2. METHODOLOGY

a) The used method

Emissions were calculated using the IPCC Tier 1 sectoral approach.

b) Activity data

Data was taken from the energy balances (See Annex D), which were compiled based on the data sources described in Paragraph 3.2.2.b.

c) Emission factors

Country specific net calorific valueswere used to convert the amount of consumed fuel from physical units into energy units. Fctors from the IPCC 1996 standard values of carbon emission were used. These factors are provided in Table 3.3. Methane and nitrous oxide emission factors are provided in Table 3.19 below.

TABLE 3-19 - METHANE AND NITROUS OXIDE EMISSION FACTORS FOR COMMERCIAL/RESIDENTIAL/ AGRICULTURE/FISHERY/FORESTRY SOURCE-CATEGORIES (KG/TJ)

GHGs	Coal	Natural gas	Oil products	Wood
CH_4	300	5	10	300
N_2O	1.4	0.1	0.6	4.0

3.2.10. NON-CO2 EMISSIONS FROM FUEL COMBUSTION

Non-CO2 emissions, such as CO, NOx, NMVOC, were calculated using the Tier 1 approach from fuel combustion. The Tier 1 methodology for non-CO2 gases estimates emissions by applying emission factors to fuel statistics, which are organised by sector. In reality, emissions of these gases depends 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 a detailed data, the Tier 1 methodology was used, it ignores these refinements. Table 3.20 provides estimates of non-CO2 emissions from fuel combustion for 2010-2013.

TABLE 3-20 - NON-CO_2 EMISSIONS FROM FUEL COMBUSTION FOR 2010-2013 PERIOD

Non-CO_2 From Fuel Combustion (Tier 1) Gg	2010	2011	2012	2013
CO	242	228	305	254
Nox	32	37	39	41
NMVOCs	40	39	47	41

3.3. FUGITIVE EMISSIONS

3.3.1. DESCRIPTION OF SOURCE-CATEGORY AND CALCULATED EMISSIONS

Fugitive emissions comprise methane (CH_4) emissions from mining and processing of coal, and methane emissions from the activity related to oil and natural gas. In this sector, the following subcategories are reviewed according to the methodology:

- Solid fuels (1B1);
    - Coal mining
    - Post-mining activities
- Oil production and processing (1B2a);
    - Oil production;
    - Oil processing;
- Natural Gas production, transmission and distribution (1B2b)
    - Natural gas production/processing;
    - Natural gas transmission and distribution.

The methane emission trend from the fugitive emissions subsector are provided in Table 3.20.

TABLE 3-21 - METHANE FUGITIVE EMISSIONS (GG)

Source	1990	1995	2000	2005	2010	2011	2012	2013
1B1. Solid fuel transformation	12.78	0.57	NO	NO	3.58	4.72	5.64	5.4
1B2. Oil and natural gas	113.8	42.73	113.3	56.96	69.83	91.35	98.68	86.01
Total fugitive emissions CH_4	126.6	43.3	113.3	56.96	73.41	96.07	104.3	91.41
Total fugitive emissions in $CO_{2eq.}$	2,658	909	2,379	1,196	1,542	2,017	2,191	1,920

As can be seen from the Table, the dominant subsector is the oil and natural gas sector, 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 increased as well, which is due to the intensification of mining of this fuel in Georgia. Below both source subcategories are described separately.

Fugitive Emissions from Solid Fuel Mining and Transformation

3.3.1.1. DESCRIPTION OF THE SOURCE CATEGORY AND CALCULATED EMISSIONS

Although the mining of coal from underground layers was well developed in Georgia during the Soviet period, later coal mining decreased considerably. From 2009, coal mining started to rise again and, respectively, fugitive emissions from this sub-category increased. Emissions data is provided in Table 3.21 below.

TABLE 3-22 - METHANE EMISSIONS (GG) FROM UNDERGROUND MINES DURING COAL MINING AND TREATMENT

Source	2010	2011	2012	2013
Extraction	3.14	4.14	4.95	4.74
Post-mining treatment	0.44	0.58	0.69	0.66
Total CH_4	**3.58**	**4.72**	**5.64**	**5.4**
Total in $CO_{2eq.}$	**75.18**	**99.12**	**118.44**	**113.40**

3.3.1.2. METHODOLOGY

a) Used method

The Global Average Method – GAM based Tier 1 approach from the 1996 IPCC Manual was used. This simple method calculates methane emissions by multiplying the mined coal amount by the global average emission factor from underground mines. The GAM method can be used in cases when data about the mining of coal from underground mines are available, while other, more detailed data, is lacking.

Tier 1 formula is as follows:

$$CH_4 \text{ emissions (Gg)} =$$

$$\text{Coal Production } (10^6 \text{ t})$$

$$\times \text{ Emission Factor } (m^3\ CH_4/\text{ tonne coal})$$

$$\times \text{ Conversion Factor } (Gg\ CH_4/10^6\ m^3\ CH_4)$$

The conversion factor converts methane volume into weight, i.e., it represents methane density (ρ) at 20°C temperature and 1 atmosphere pressure conditions, ρ=0.67 Gg/ 10^6 m^3.

b) Activity data

Information about coal mining in Georgia in 2010-2013 were obtained from the National Statistics Office of Georgia (GEOSTAT).

TABLE 3-23 - COAL MINING

Fuel	2010	2011	2012	2013
Lignite (Gg)	267.70	352.90	421.80	404.19

c) Emission factors

According to the IPCC 1996 average, at a global level, the coal mining emission factor varies in the range from 10-25 m^3 CH_4/ton mined coal. To calculate the average value, 17.5 m^3 CH_4/ton of mined coal was used.

For post mining activity, the IPCC 1996 recommends the use of the global average emission factor value in the range: 0.9 - 4 m^3 CH_4 /ton of mined coal. To calculate, the average value 2.45 m^3 CH_4/ton of mined coal was used.

3.3.2. METHANE EMISSIONS FROM OIL AND NATURAL GAS RELATED ACTIVITIES

3.3.2.1. SOURCE-CATEGORY DESCRIPTION AND CALCULATED EMISSIONS

In general, this category comprises methane emissions in the process of extraction, processing, transportation and distribution of oil and natural gas. The most crucial component of this category is methane emissions in the course of oil and gas production, and emissions from all activities related to natural gas related.

The sources of fugitive emissions from oil and gas systems are as following: emissions in the course of regular operation, e.g., emissions during venting and flaring, leakages from process valves, emissions in the course of operation, and emissions in case of accidents and delays in the system.

This source-category is comprised of two sub-categories: 1B2a – source-category Oil Production and Processing and 1B2b – Natural Gas Production, Transmission and Distribution. Natural gas distribution accounts for the highest share in these emissions.

TABLE 3-24 - METHANE EMISSIONS (GG) FROM OIL AND NATURAL GAS RELATED ACTIVITIES

Source	2010	2011	2012	2013
Oil	**0.01**	**0.01**	**0.005**	**0.01**
Extraction	0.01	0.01	0.005	0.01
Processing	0	0	0	0
Natural Gas	**69.83**	**91.35**	**98.67**	**86.01**
Production	0.11	0.08	0.07	0.07
Transmission and distribution	69.72	91.27	98.6	85.94
Total CH_4	**69.84**	**91.36**	**98.675**	**86.02**
Total in $CO_{2eq.}$	1,467	1,919	2,072	1,806

3.3.2.2. METHODOLOGY

a) Used method

In Georgia, oil and natural gas are extracted at a small scale, and this has been taken into account in the process of the methodology selection.

For assessing fugitive emissions in the course of oil extraction, the Tier 1 method was used; this approach uses relevant aggregate emission factors of extraction and quantitative data on extraction:

$$\textbf{CH}_4\textbf{ emissions (Gg) =}$$

$$\textbf{Oil extracted (10}^6\textbf{ tonnes)}$$

$$\textbf{X Conversion factor (PJ/10}^6\textbf{ tonnes)}$$

$$\textbf{X Emission factor (kg CH}_4\textbf{/PJ) X 10}^{-6}$$

The methodological approach Tier 1 assessment of fugitive emissions from natural gas production, uses aggregate quantitative data and emission factors.

$$\textbf{CH}_4\textbf{ emissions (Gg) =}$$

$$\textbf{Gas production (10}^6\textbf{ m}^3\textbf{)}$$

$$\textbf{X Conversion factor (PJ/ 10}^6\textbf{ CH}_4\textbf{)}$$

$$\textbf{X Emission factor (kg CH}_4\textbf{/PJ) X 10}^{-6}$$

Conversion factors for oil and natural gas are provided in Table 3.28.

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

$$\mathbf{CH_4\ emissions\ (Gg) =}$$

$$\mathbf{Gas\ loss\ (10^6\ m^3)\ X\ Methane\ content\ in\ gas\ (\%)}$$

$$\mathbf{X\ Conversion\ factor\ (t\ CH_4/m^3\ CH_4)\ X\ 1000}$$

This methodology corresponds to the methodology 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 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.

b) Activity data

The Georgian National Statistics office is the source of the data on oil and natural gas extraction/production. This data isreflected in the energy balances and provided in Table 3.24.

TABLE 3-25 - OIL AND NATURAL GAS PRODUCTION IN GEORGIA

Fuel |Year	2010	2011	2012	2013
Oil (t)	51,440	49,945	44,100	47,863
Natural Gas (mln.m^3)	8.10	5.80	5.40	5.42

Assessments about natural gas losses were made based on the information obtained from the reports of the Georgia National Energy and Water Regulatory Commission[27] and Gas balances provided by Ministry of Energy. According to the information, natural gas losses in the transportation system were about 0.83% of the total supply in 2010, while it was about 0.17% in 2013.

Natural gas losses are quite high in the gas distribution systems of Georgia. These losses are made up off operational (technological and accidents) and commercial losses. The amount of losses in gas pipelines depends on a number of 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 November 18, 2010 Decree N26, 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 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 2010-2011 years in the GHGs emission inventory.

[27] http://www.gnerc.org/index.php?m=572

Table-3.27 shows natural gas transportation and distribution losses in Georgia during 2010-2013.

TABLE 3-26 - NATURAL GAS TRANSMISSION LOSSES

Year	2010	2011	2012	2013
Natural Gas supply to Georgia (mln.m^3)	1,179	1,856	2,038	1,919
Natural Gas transit through Georgia to Armenia (mln.m^3)	1,440	1,609	2,000	2,000
Total natural gas transmitted through high pressure pipelines (mln.m^3)	**2,619**	**3,465**	**4,038**	**3,919**
Transmission losses, %	0.83%	0.98%	0.89%	0.17%
Transmission losses, (mln.m^3)	**21.78**	**33.86**	**35.81**	**6.48**

TABLE 3-27 - NATURAL GAS DISTRIBUTION LOSSES

Year	2010	2011	2012	2013
Natural gas consumption of Georgia (mln.m3)	**959**	**1,194**	**1,300**	**1,408**
Distribution losses (%)	9%	9%	9%	9%
Distribution losses, (million m^3)	**86**	**107**	**117**	**127**

TABLE 3-28 - NATURAL GAS TRANSMISSION AND DISTRIBUTION LOSSES (MILLION M^3)

Year	2010	2011	2012	2013
Transmission losses	22	34	36	6
Distribution losses	86	107	117	127
Total	**108**	**141**	**153**	**133**

c) Emission factors

For the former Soviet countries, the 1996 IPCC recommends to use regional emission factors for oil and natural gas production. The IPCC methodology provides a range of these factors. In Georgia, the middle point of these ranges from these categories was used to calculate emissions (Table 3.28).

TABLE 3-29 - METHANE-CH_4 EMISSION FACTOR FROM OIL AND NATURAL GAS PRODUCTION (KG/PJ)

Source	Reference	Range	Average
Oil extraction	Extracted oil	300 - 5 000	2 650
Gas production: fugitive emissions from wells	Produced gas	218 000-567 600	392 800

4. INDUSTRIAL PROCESSES

4.1. SECTOR OVERVIEW

This chapter describes methodologies used to estimate GHG emissions, as well as references activity data and emission factors reported under Industrial Processes for 2010 to 2013. GHG Emissions from this sector, cover emissions from the following categories: mineral products (2A), chemical industry (2B), metal production (2C), other industries such as paper, drinks and food production, and consumption of halocarbons and SF6 (2F) in TABLE 4.1.

TABLE 4.1. EMISSIONS FROM THE INDUSTRIAL PROCESSES IN GEORGIA IN 2010-2013 (GG CO2 EQ.)

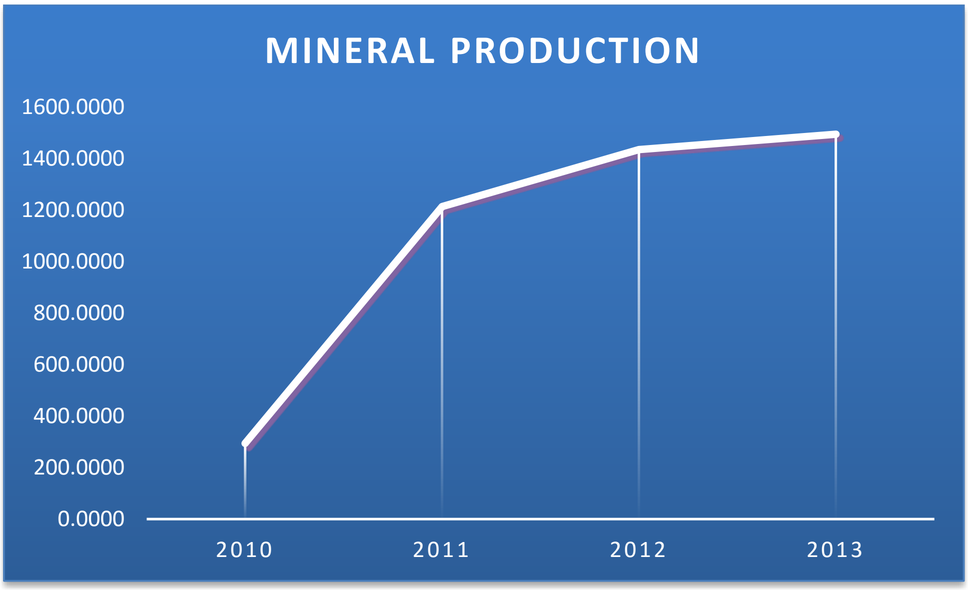
Source-Category	2010	2011	2012	2013
2A Mineral Industry	294.7	1215.3	1436.7	1496.9
2A1 Cement Production	254.6	489.2	601.4	599.9
2A1 Lime Production	35.4	720.7	830.5	890.9
2A3 Limestone and Dolomite Use	0.4	1.2	1.9	2.6
2A7 Glass Production	4.2	4.2	2.8	3.5
2B Chemical Industry	1010.1	1060.5	1065.1	1075.1
2B1 Ammonia Production	214.3	242.3	254.6	250.7
2B2 Nitric Acid Production	795.8	818.2	810.5	824.4
2C Metal Production	339.5	411.3	445.0339	435.8962
2C1 Iron and Steel Production	3.2869	10.7	14.3	17.9
2C2 Ferroalloys Production	336.3	400.5	430.8	418.1
2F Consumption of Halocarbons and Sulphur Hexafluoride	0.2	0.3	0.3	0.3
2F6 SF6 Emissions from Appliances	0.2	0.3	0.3	0.3
Total from IP sector	1644.5	2687.3	2947.1	3008.2
2F1 Refrigeration and Air Conditioning Equipment	137.5	238.2	354.4	208.0

Only non-energy industrial activities related emissions are considered in this sector. Emissions due to fuel combustion in manufacturing industries are allocated to the IPCC Sub-category 1A2 – Fuel Combustion Activities – Manufacturing Industries and Construction (see Chapter 3). Furthermore, the chapter includes information on emissions of indirect GHGs, such as non-methane volatile organic compounds (NMVOCs), carbon monoxide, and nitrogen oxides.

4.2. Mineral Products

Emissions from the mineral production sub-category reached its highest value in 2013, with around 1496 Gg of CO_2. Compared to 2010, emissions quintupled at the end of the quantified period (FIGURE 4.). Emissions gradually increased after 2011, from 1215 to 1496 Gg of CO_2, largely caused by the increase of emissions from the lime production source category by 23 percent. The largest growth in emissions from the category was in 2011, after the country's economic crisis. The CO_2 level quadrupled from 295 Gg to 1215 Gg, due to a skyrocketed performance of Cement and Lime production processes.

FIGURE 4.1. EMISSIONS FROM THE SUB-CATEGORY OF MINERAL PRODUCTION



4.2.1. CEMENT PRODUCTION

4.2.1.1. SOURCE-CATEGORY DESCRIPTION AND CALCULATED EMISSIONS

In 2012, CO_2 emissions from the clinker production was highest during 2010 to 2013 (approximately 67% higher than at the beginning of the calculation period). Eemissions had an upward trend between 2010 and 2012, from 254.6045 to 601.4487Gg. The slight decline of emissions in the last inventory year, 2013, was 599.9462Gg. The significant increase in emissions were recorded in 2011, approximately by 48% compared to the data of 2010. Afterwards, the CO_2 emissions increased around 19%. In 2013, it decreased with 0.25%. The noteworthy growth of emissions in 2011 was mostly caused by the increase in demand of construction materials, after the country's economic crisis.

Cement Production is a key source-category with regard to CO_2 emissions. It has been a key source without interruption since 1990 (Table 1.2).

The calculated CO_2 emissions from the clinker productions are presented in Table 4.2 below.

TABLE 4.2. CO_2 EMISSIONS FROM CLINKER PRODUCTION (GG) IN 2010 - 2013

	Module	**Industrial Processes**			
	Sub-module	**Cement Production**			
	Worksheet	**2_1**			
	Sheet	**1 of 2 CO2 Emissions**			
Step 1					
Year	A Qantity of Clinker or Cement Produced (t)	B Emission Factor (t CO2/t Clinker or Cement Produced)	C CKD Correction Factor	D CO2 Emitted (t)	E CO2 Emitted (Gg)
				D=(A*B*C)	E=D/10^3
2010	489196	0.51025	1.02	254604.5042	254.6045
2011	940008.2	0.51025	1.02	489231.9677	489.2320

2012	1155621	0.51025	1.02	601448.7276	601.4487
2013	1152734	0.51025	1.02	599946.174	599.9462

The calculated emission of Sulfur dioxide from the cement production are shown in Table 4.3 below.

TABLE 4.3. SO_2 EMISSIONS (GG) FROM CEMENT AND CLINKER PRODUCTION IN 2010-2013

Module	**Industrial Processes**			
Submodule	**Cement Production**			
Worksheet	**2_1**			
Sheet	**2 of 2 SO_2 Emissions**			
Step 2				
Year	A Quantity of Cement Produced (t)	B Emission Factor (kg SO_2 /t Cement Produced)	D SO_2 Emitted (kg)	E SO_2 Emitted (Gg)
			C=(A*B)	D=C/10^6
2010	907049.3	0.3	272114.7900	0.2721
2011	1501972.3	0.3	450591.6900	0.4506
2012	1545545.9	0.3	463663.7700	0.4637
2013	1618723.3	0.3	485616.9900	0.4856

4.2.1.2. METHODOLOGY

a) Used method

CO_2 emissions from cement production are estimated, using the IPCC-GPG Tier 2 approach. In accordance with the Tier 2 method, estimating CO_2 emissions can be calculated from the clinker production, through:

$$CO_2 \text{ Emissions} = EFclinker \bullet \text{Clinker Production} \bullet \text{CKD Correction Factor}$$

Where:
The Cement Kiln Dust Correction Factor equals to 1.02.

The emission factor calculation is represented below:

$$EFclinker = 0.785 \bullet 0.65^* = 0.51025$$

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

b) Activity data

In Georgia, three clinker production plans operate (two plans 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.
Activity data – figures of clinker production was obtained from the Georgian State National Statistics Office (Table 4.4).

TABLE 4.4. THE ACTIVITY DATA OF CLINKER PRODUCTION

Clinker Production	
Year	Activity Data (t)
2010	489196
2011	940008.2
2012	1155621
2013	1152734

c) Emission factors

According to the 1996 IPCC, the emission factor is calculated as following: EF = CaO fraction × 0.785 (molecular weight ratio of CO_2 / CaO = 44.01 / 56.08). The average CaO content in cement is equal to 63.5%. Accordingly, EF = 0.635 × 0.785 = 0.4985 t CO_2 /t cement. For clinker EF = 0.5071 CO_2 ton / ton of produced clinker.[28]

In this sub-sector, sulfur dioxide (SO_2) emissions are calculated as well, its emission rate according to the 19996 IPCC is 0.3 kg of SO_2 / ton of product.

4.2.2. LIME PRODUCTION

4.2.2.1. SOURCE-CATEGORY DESCRIPTION AND CALCULATED EMISSIONS

The highest emissions from the Lime Production in Georgia were in 2013, with 890.9260 Gg of CO_2 during 2010 – 2013. In 2010, the CO_2 emissions reached only 35.4440 Gg, approximately 3.98% of its value recorded for 2013. Since Lime is mostly used for the cement industry in Georgia, its production performance is highly influenced by the demand of cement. Emissions skyrocketed from 2010 to 2011 by almost 20 times. Afterwards, the emission curve increased gradually by about 19.11%.

The calculated carbon dioxide emissions from lime production in Georgia are presented in Table 4.5.

TABLE 4.5. CO_2 EMISSIONS FROM LIME PRODUCTION FROM 2010 TO 2013

	Module	Industrial Processes			
	Submodule	Production of Lime			
	Worksheet	2_2			
	Sheet	1 of 1 CO_2 Emissions			
Step 1					
Year	A Quantity of Lime Produced (t)	B Emission Factor (t CO_2/t Quicklime or Dolomitic Lime Produced)	C Hydrated Lime Correction Factor	D CO_2 Emitted (t)	E CO_2 Emitted (Gg)
				D=(A*B*C)	E=D/10^3
2010	43039	0.849	0.97	35443.9900	35.4440
2011	875083	0.849	0.97	720657.1030	720.6571
2012	1008451	0.849	0.97	830489.6520	830.4897
2013	1081838	0.849	0.97	890926.0481	890.9260

[28] 2006 IPCC Guidelines for National Greenhouse Gas Inventories. http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

Lime Production is a key source-category with regard to CO_2 emissions.

4.2.2.2. METHODOLOGY

a) Used method

In accordance with the GPG 2000, CO2 emissions from the Lime production are calculated by the following equitation.

CO_2 Emissions = Emission Factor (EF) ● Lime Production ● Hydrated Lime Correction Factor

Where:

The emission factor equals to 0.849

The hydrated lime default correction factor is 0.97.

b) Activity data

A major producer of lime in Georgia is JSC "Heidelberg Cement." It owns approximately 72% of the lime production in Georgia. Lime is also produced by several smaller enterprises in Kutaisi, Surami, Dzirula, Ozurgeti, and Zugdidi. All of them mainly use limestone as raw material, and use a relatively lesser amount of dolomite. There is no accurate statistics on data of used raw materials. According to the data supplied by the manufacturer[29], to get 1 ton of lime it needs approximately 1.75 tonnes of raw materials. The production technology is mostly based on the wet method.

c) 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 ton of lime, for dolomite lime - 913 kg of CO_2 per ton of lime. Due to lack of accurate data, the average value - 849 kg of CO_2 per ton of lime - was used[30]. Furthermore, since the wet production technology is used to produce the largest amount of lime in Georgia, the default hydrated lime correction factor 0.97, was used in calculations.

4.2.3.LIMESTONE AND DOLOMITE USE

4.2.3.1. SOURCE-CATEGORY DESCRIPTION AND CALCULATED EMISSIONS

The source-category of Limestone and Dolomite Use, covers emissions related to limestone use in metal production in accordance with the IPCC 2000 GPG. Other emissions from the use of limestone and dolomite are accounted for in the IPCC sub-categories Cement Production and Other – Glass Production.

The largest amount of emissions were in 2013, with approximately 2.6 Gg of CO_2. During this four-year period, emissions have an upward trend, increasing almost three times in 2011 compared to 2010. The performances of Steel factories in Georgia, which improved production profile after the economic crisis, is the main reason for the increase. Emissions from the source category are shown in Table 4.6.

TABLE 4.6. CO_2 EMISSIONS FROM THE LIMESTONE USE IN GEORGIA IN 2010-2013

Module	**Industrial Processes**
Submodule	**Limestone and Dolomite Use**
Worksheet	**2_3**
Sheet	**1 of 1 CO_2 Emissions**

[29] industria_kiri@posta.ge; contacts@rustavisteel.com
[30] http://www.ipcc-nggip.iges.or.jp/public/gp/english/3_Industry.pdf. page 2.5; Table 2.1)

[redacted]

Year	A Quantity of Limestone Used (t)	B Emission Factor (kg CO_2/t Limestone Used)	C CO_2 Emitted (kg)	D CO_2 Emitted (Gg)
			D=(A*B)	E=D/10^6
2010	1003.49625	440	441538.3500	0.4415
2011	2680.8775	440	1179586.1000	1.1796
2012	4301.53	440	1892673.2000	1.8927
2013	5961.62125	440	2623113.3500	2.6231

Limestone and Dolomite use is a key source-category with regard to CO_2 emissions.

Methodology

a) Used method

In accordance with the IPCC 1996 Revised Guideline, CO_2 emissions from Limestone use is calculated by the following equitation.

$$CO_2 \text{ Emissions} = \text{Emission Factor (EF)} \bullet \text{Limestone Used}$$

Where:

The emission factor equals to 440 kg/per ton of Limestone

b) Activity data

The data of limestone use in the Metallurgy sector were collected from two factories operating in Georgia (Rustavi Metallurgy and Geosteel). During steel production, lime is used to process crust steel. Each factory provided data for lime used and the limestone it contained. The materials are attached to the submission as confidential documents.

c) Emission factors

In accordance with the IPCC Revised Guideline, the default emission factor was used for the calculations.

4.2.4. SODA PRODUCTION

This source category does not exist in Georgia.

4.2.5. ASPHALT PRODUCTION

4.2.5.1. SOURCE-CATEGORY DESCRIPTION AND CALCULATED EMISSIONS

Asphalt is a tarry gray mass, used to cover roads, streets, squares surface. There is natural and artificial asphalt. Natural asphalt is made from oil. Under the influence of evaporation and hyper-genesis of light fractions, and as a result of oxidation of heavy fractions, the oil turns into thick, viscous fluid, and then solidifies.

Artificial asphalt is a mixture of bitumen and crushed mineral fillers (mainly limestone). It contains paraffin and petroleum oils. Sand, pebbles and gravel mixed with asphalt, are widely used for roofing, floors and pavements, road paving etc. Georgia produces mainly artificial asphalt.

The calculated carbon monoxide emissions from asphalt production are presented in Table 4.7, and NMVOCs emissions in Table 4.8.

TABLE 4.7. CO EMISSIONS FROM ASPHALT PRODUCTION IN 2010-2013

Asphalt-Concrete Production		Emission Factor (kg CO /t Asphalt)	CO Emission (kg)	CO Emission (Gg)
Year	Ton		C = (AxB)	$D=C/10^6$
2010	371 653	0.0095	3 531	0.004
2011	173 316	0.0095	1 647	0.002
2012	444357.7	0.0095	4 221	0.004
2013	464619.1	0.0095	4 414	0.004

TABLE 4.8. NMVOCS EMISSIONS FROM ASPHALT PRODUCTION IN 2010-2013

Asphalt-Concrete Production		Emission Factor (kg NMVOCs /t asphalt)	NMVOCs Emission (kg)	NMVOCs Emission (Gg)
Year	Ton		C = (AxB)	$D=C/10^6$
2010	371 635	0.0475	17 653	0.018
2011	173 316	0.0475	8 233	0.008
2012	444357.7	0.0475	21106.99	0.021
2013	464619.1	0.0475	22069.41	0.022

4.2.5.2. METHODOLOGY

a) Method used

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

b) Activity data

This sub-sector considers asphalt producing enterprises (oil refineries are not considered) and its usage. In Georgia, the asphalt production technology is as following: after processing oil products, the remaining mass Bitumen and fillers (cement, lime) are stirred in mobile or stationary units, about 30-50 km from where the asphalt will be applied. 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. They are bitumen and asphalt emulsion. The latter is mainly composed of water and a small, or even zero, amounts of solvents. During the discussed period, the main part of asphalt in Georgia was produced by several large and small enterprises. They produced the so-called hot asphalt mixture, through a similar technology. The data was provided by the Georgian statistics office.

c) 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[31], whereas the technology of the asphalt production (saturation without emission) therefore is: for NMVOCs - 0.0475, while for CO - 0.0095 kg / ton of asphalt.

4.2.6. ROAD PAVING WITH ASPHALT

Since accurate data is not available, emissions cannot be calculated for this source-category.

4.2.7. GLASS PRODUCTION

4.2.7.1. SOURCE-CATEGORY DESCRIPTION AND CALCULATED EMISSIONS

This subcategory considers carbonate thermal processing productions, of which one is glass production. CO_2 emissions from glass production are included in this category.

Emissions from the source-category of Glass Production are significantly low in Georgia. The highest emissions occurred during 2010 and 2011. Afterwards, the emitted amount of CO_2 declined by 32% and reached 2.85 Gg. In the last estimation year, emissions increased by 22% compared to the value recorded in 2012.

The calculated quantities of emitted NMVOCs and CO_2 from glass production in Georgia are presented in Table 4.9 and Table 4.10.

TABLE 4.9. NMVOCS EMISSIONS FROM GLASS PRODUCTION

Glass Production		Emission Factor (kg NMVOCs /t Glass)	NMVOCs Emissions (kg)	NMVOCs Emissions (Gg)
Year	Tonnes		C = (AxB)	$D=C/10^6$
2010	35 000	4.5	157 500	0.16
2011	35 000	4.5	157 500	0.16
2012	23727	4.5	106771.5	0.11
2013	28974	4.5	130383	0.13

TABLE 4.10. CO_2 EMISSIONS FROM GLASS PRODUCTION

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

Modul		Industrial Process			
Submodul		Production and use of different mineral resources			
Worksheet		2 A 3			
Sheet		*CO_2 –emission from glass production*			
A Glass Production		B EF of Glass Production	C Share of Ground Glass Used (ratio)	D CO_2 Emission (t)	E CO_2 Emission (Gg)
Year	tonnes	(t CO_2/t Glass)	%	D=A.B.(1-C)	$E=D/10^3$
2010	35 000	0.2	0.4	4 200	4.20
2011	35 000	0.2	0.4	4 200	4.20
2012	23727	0.2	0.4	2847	2.85
2013	28974	0.2	0.4	3476	3.48

4.2.7.2. METHODOLOGY

a) Method used

The IPCC 1996 methodology was used, according to which, only NMVOCs emissions from this sub-sector were considered. From 2006, the IPCC methodology includes CO_2 emissions as well. To calculate, three levels were used. Based on the Tier 1 approach, CO_2 emissions were calculated with the following formula:

$$E_{CO2} = M.\ EF.\ (1\text{-}CR),$$

Where:

E_{CO2} is emitted carbon dioxide quantity, Gg;

EF - emission factor, ton of CO_2 / ton of glass;

CR - blamed on the initial charge of broken glass, fractional.

NMVOCs emission were estimated by multiplying the emission factor (tonnes of NMVOCs emitted from glass production) by the number of tonnes of glass produced during the year.

b) Activity data

In Georgia, glass production is run by JSC Mina - Ksani glass factory, located in the Mtskheta region, in Ksani. Currently, the plant uses four recipes of blend for green, antique green, blue and light green glass bottle making. The Ksani glass factory started operrating in 1987, with three furnace and eight production lines, its annual capacity was 40 thousand tonnes. In 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 packet of shares, and the plant’s capacity increased up to 18 thousand tonnes. At the end of 2002, a second furnace was launched, with two production lines, resulting in a 48 thousand tonnes / year capacity. In 2008, the first furnace stopped working, due to of the end of its operational life. Currently, the second furnace operates with a capacity of 35 thousand tonnes / year.

The activity data was provided by the Ksani Glass Factory.

TABLE 4.11. THE ACTIVITY DATA OF GLASS PRODUCTION

Glass Production	
Year	Activity Data (t)
2010	35 000*
2011	35 000*
2012	23 727
2013	28 974

** Data from the 3rd National Communication of Georgia*

c) Emission factors

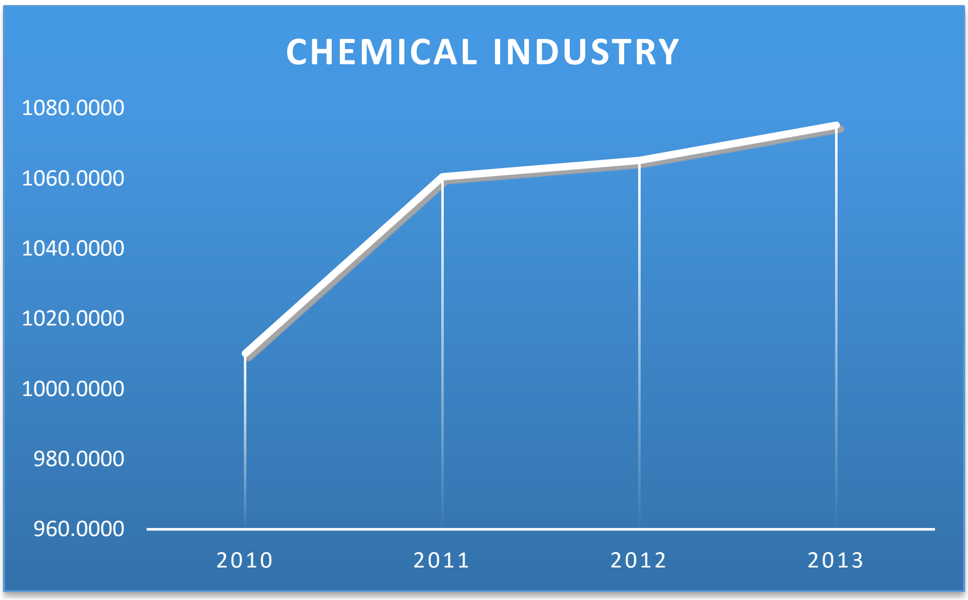
NMVOCs emission were determined by the weight of melted glass mass. The plant mainly uses a similar blend composition, and produces the glass is with a similar technology. The IPCC 1996 Methodology proposes 4.5 kg of NMVOCs / ton of produced glass as emission coefficient.

The IPCC 2006 methodology presents a CO2 emission actor - 0.2 ton of CO2 / a ton of glass, which is exactly the same as the CO2 emission coefficient calculated on the basis of chemical composition of glass blend used at the Ksani plant (a ton of raw materials gives 0.85 ton of glass and the mass loss is about 17%, therefore, the emission coefficient is 0.17 / 0.85 = 0.2 ton of CO2 / a ton of produced glass).

4.3. CHEMICAL INDUSTRY

The Chemical Industry sub-sector considers emissions from Ammonia Production and Nitric Acid Production source-categories. Emissions increased between 2010 and 2013, by approximately 6 percent. The largest increase was recorded in 2011, from 1081 Gg to 1155 Gg of CO_2 eq. Afterwards, emissions slightly declined by 0.5%, due to the reduction of producing nitric acid. At the end of the period, emissions increased again by 1% compared to the value calculated for 2012. The emission trend is illustrated in Figure 4.2.

FIGURE 3.2. THE EMISSION TREND FOR THE CHEMICAL INDUSTRY



4.3.1. AMMONIA PRODUCTION

4.3.1.1. SOURCE-CATEGORY DESCRIPTION AND CALCULATED EMISSIONS

Most of the ammonia in Georgia is produced by the Haber-Bosch process, a synthesis of ammonia: nitrogen and hydrogen react. The required hydrogen is a product of natural gas conversion. Ammonia is obtained at 25-30 MPa pressure and 470-550° C temperature from a nitrogen and ammonia mixture with an iron catalyst in place.

As ammonia is mainly used to produce chemical fertilizers, it is often produced in large amounts at fertilizer factories. The carbon dioxide from the production of ammonia can be used to obtain fertilizer - urea (carbamide) and dry ice. However, since after applying carbon dioxide in the form of urea fertilizer or dry ice into the soil, it evaporates into the atmosphere, the intermediate retention of CO2 in products and production processes will not be considered.

In 2010, emissions were about 214 Gg CO_2 by 14 percent lower than the value recorded at the end of the period. From 2011 to 2013, emissions increased slightly, with approximately 0.2 percent. The emission enhancement during 2011 mostly relates to the industry's recovery after Georgia's economic crisis.

The calculated CO2 emissions for the years 2010-2013 are given in Table 4.12.

TABLE 4.12. CO_2 EMISSIONS FROM AMMONIA PRODUCTION CALCULATED ON BASED ON QUANTITY OF PRODUCTS IN 2010-2013

Module		**Industrial Processes**			
Submodule		**AMMONIA PRODUCTION**			
Worksheet		**2_6**			
Sheet		**1 OF 3 TIER 1a - CO2 EMISSIONS**			
Step 1					
Year	A Qantity of Ammonia Produced (t)	B Emission Factor (t CO2/t Ammonia Produced)	C Conversion Ratio	D CO2 Emitted (t)	E CO2 Emitted (Gg)
				C=(A*B*C)	E=D/10^6
2010	120670941.7	0.4843	3.67	214283435.9	214.3
2011	136428943	0.4843	3.67	242265969.3	242.3
2012	143361735.3	0.4843	3.67	254576990.8	254.6
2013	141166228	0.4843	3.67	250678282.1	250.7

In Table 4.13, NMVOCs, CO and SO2 emissions from ammonia production calculated for 2010-2011 are given.

TABLE 4.13. NMVOCS, CO AND SO_2 EMISSIONS FROM AMMONIA PRODUCTION IN 2010-2013.

		Module	Industrial Processes	
		Submodule	AMMONIA PRODUCTION	
		Worksheet	2_6	
		Sheet	3 OF 3 TIER 1b - NMVOC, CO, SO_2 EMISSIONS	
Step 3				
Year	A Quantity of Ammonia Produced (t)	B Emission Factor (Kg pollutant/t Ammonia Produced)	C NMVOC Emitted (kg)	D NMVOC Emitted (Gg)
			C=(A*B)	D=C/10^6
2010	189860	4.7	892342	0.8923
2011	220089	4.7	1034418	1.0344
2012	221655	4.7	1041778	1.0418
2013	220546	4.7	1036566	1.0366
			CO Emitted	CO Emitted
2010	189860	7.9	1499894	1.4999
2011	220089	7.9	1738703	1.7387
2012	221655	7.9	1751074	1.7511
2013	220546	7.9	1742313	1.7423
			SO_2 Emitted	SO_2 Emitted
2010	189860	0.03	5695	0.0057
2011	220089	0.03	6602	0.0066
2012	221655	0.03	6649	0.0066
2013	220546	0.03	6616	0.0066

4.3.1.2. METHODOLOGY

a) Method used

The Tier 1b of the IPCC 1996 guideline was used to calculate emissions from the Ammonia Production source-category. The approach was based on national data from ammonia production process.

b) Activity data

Ammonia production data was obtained from the State National Statistics Office of Georgia, as well as from Azoti, the Ammonia producing plant in Rustavi. The performance of the ammonia producing factory, in 2010-2013, is given in Table 4.14.

TABLE 4.14. AMMONIA PRODUCTION DATA FOR 2010-2013

Ammonia Production	
Year	Activity Data (t)
2010	189 860*
2011	220 089

2012	221 655
2013	220 546

** Data from the 3rd National Communication*

c) Emission factors

The typical value of the emission coefficient, recommended by the revised IPCC 1996, is 1.5 tonnes of carbon dioxide per a ton of produced ammonia. This does not include natural gas used as fuel. Ammonia production also emitts NOx, NMVOCs, CO and SO_2 in the atmosphere. Their emissions are calculated by using default emission factors proposed in the IPCC 1996 methodology. Used emission coefficients of trace admixtures are given in Table 4.15.

TABLE 4.15. EMISSION COEFFICIENTS OF TRACE ADMIXTURES EMITTED FROM AMMONIA PRODUCTION[32] (KG OF GAS / TON OF AMMONIA)

Gases Emitted	NMNMVOCs	CO	SO_2
EFEF	4.7	7.9	0.03

4.3.2. NITRIC ACID PRODUCTION

4.3.2.1. SOURCE-CATEGORY DESCRIPTION AND CALCULATED EMISSIONS

Nitric acid (HNO3) is produced as a result of catalytic oxidation of ammonia at a high temperature. During this process, nitrous oxide (N2O) and nitrogen oxides (NOx-s) are produced as indirect products. The quantity of emitted gases is proportional to the quantity of used ammonia. Their concentration in exhaust gases depends on the plant's technology and level of emissions' control. Taking into account the available statistical data, and above listed assumptions, the calculated nitrogen oxide emissions are given in Table 4.16.

TABLE 4.16. NITROGEN OXIDES EMISSIONS FROM NITRIC ACID PRODUCTION IN 2010-2013

	Module	**Industrial Processes**		
	Submodule	**NITRIC ACID PRODUCTION**		
	Worksheet	**2_6**		
	Sheet	**I OF 1 N_2O AND NOx EMISSIONS**		
Step 1				
Year	A Quantity of Nitric Acid Produced (t)	B Emission Factor (kg N_2O/t Nitric Acid Produced)	C N_2O Emitted (Kg)	D N_2O Emitted (Gg)
			C=(A*B)	D=C/10^6
2010	380304	6.75	2567052	2.5671
2011	391010	6.75	2639317	2.6393
2012	387350	6.75	2614612	2.6146

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

2013	393984	6.75	2659392	2.6594
			NO_X	NO_X
2010	380304	12	4563648	4.5636
2011	391010	12	4692120	4.6921
2012	387350	12	4648200	4.6482
2013	393984	12	4727808	4.7278

4.3.2.2. METHODOLOGY

a) Method used

The tier 1 methodology was used to calculate emissions from the source-category of nitric acid production, since the activity data covers the amount of nitric acid produced per annum, in accordance with the IPCC 1996 guideline.

b) Activity data

The source of Nitric acid production data is nitric acid production – Rustavi's 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 steam at average pressure.

c) Emission factors

According to the IPCC 1996, for factories with intermediate pressure technology, the emission coefficient for nitrous oxide (N2O) is equal to 6.75 [(6 + 7.5) / 2] kg of N2O / ton of HNO3, while for NOx-s, in case of lack of data of technological details, is 12.0 kg of NOx / ton of HNO3.

4.3.3. ADIPIC ACID PRODUCTION

This source category does not exist in Georgia.

4.3.4. CARBIDE PRODUCTION

This source category does not exist in Georgia.

4.3.5. OTHER CHEMICALS PRODUCTION

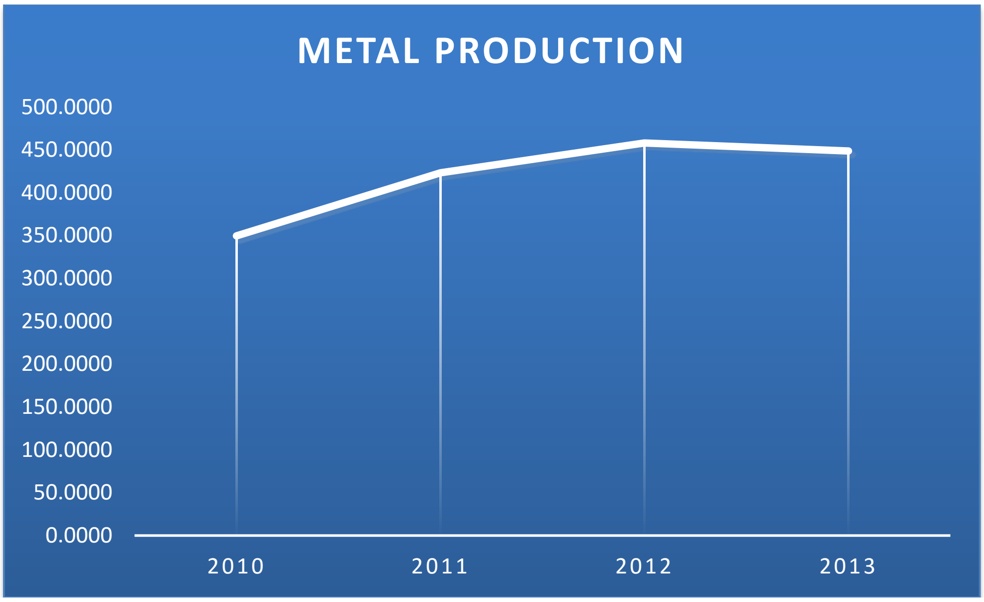
This source category does not exist in Georgia.

4.4. METAL PRODUCTION

The sub-sector of Metal Production covers steel and ferroalloys processing in Georgia. Emissions from ferroalloys production are about 26 times higher, than emissions from steel production. The significant difference among the source-categories in produced emissions relates mostly to the technology used in steel production. In Georgia, steel manufacturing uses Electric Arc Furnace, characterized as a low emitter. Hence, the emission trend for the Metal Production sub-sector is mostly maintained by the ferroalloys production source-category. The trend is illustrated in Figure 4.3 below.

The highest emissions in the sub-category were 458 Gg of CO2 in 2012. The trend increased between 2010 and 2012. At the end of calculated period, emissions declined due to reduced ferroalloys production.

FIGURE 4.3. THE EMISSION TREND FROM THE METAL PRODUCTION IN 2010-2013



4.4.1. CAST IRON AND STEEL PRODUCTION

4.4.1.1. SOURCE-CATEGORY DESCRIPTION AND CALCULATED EMISSIONS

Emissions from the metal production source-category rose during the four-year period (Table 4.17). In 2010, emissions were more than five times less, than in 2013. The largest increase of emissions were recorded in 2011, with 70% comparing to the 2010 level.

The calculated amount of emitted CO2 in 2010-2013, during the production of steel, are given in Table 4.17 below.

TABLE 4.17. CO2 EMISSIONS FROM THE STEEL PRODUCTION IN 2010-2013

Module	**Industrial Processes**				
Submodule	**METAL PRODUCTION**				
Worksheet	**2_11**				
Sheet	**1 OF 11 TIER 2 - CO2 EMISSIONS**				
Step 1					
Year	A Mass of Reducing Agent (t)	B Emission Factor (t CO2/t Reducing Agent)	C (Carbon Content of Ore minus Carbon Content of Metal) x 3.67 (t CO2/t Carbon)	D CO2 Emitted (t)	E CO2 Emitted (Gg)
				D=A*B+C	E=D/10^3
2010	104326	0.005	2765.302061	3286.9321	3.2869
2011	156784	0.005	9958.409577	10742.3296	10.7423
2012	207341	0.005	13224.2945	14260.9995	14.2610
2013	251204	0.005	16594.40596	17850.4260	17.8504

Emissions of trace admixtures are presented in TABLE 4.18. TRACE ADMIXTURES' EMISSIONS FROM STEEL PRODUCTION 2010-201.

TABLE 4.18. TRACE ADMIXTURES' EMISSIONS FROM STEEL PRODUCTION 2010-2013

Steel Production		**EF (g gas / t steel)**		**Emissions (g)**	**Emissions (Gg)**
Year	Tonnes			C = (AxB)	D = C/109
2010	104 326	NOx	40	4173040	0.0042
		NMVOCs	30	3129780	0.0031
		CO	1	104326	0.0001
		SO_2	45	4694670	0.0047
2011	156 784	NOx	40	6271360	0.0063
		NMVOCs	30	4703520	0.0047
		CO	1	156784	0.0002
		SO_2	45	7055280	0.0071
2012	207 341	NOx	40	8293640	0.0083
		NMVOCs	30	6220230	0.0062
		CO	1	207341	0.0002
		SO_2	45	9330345	0.0093
2013	251 204	NOx	40	10048160	0.0100
		NMVOCs	30	7536120	0.0075
		CO	1	251204	0.0003
		SO_2	45	11304180	0.0113

4.4.1.2. METHODOLOGY

a) Method used

The tier 2 method from IPCC GPG 2000 was used to calculate CO2 emissions from the steel production. In Georgia, steel manufacturing processes use electric arc furnace EAF. Subsequently, the tier 2 approach provides the following formula to calculate emissions:

Emissions crude steel = (Mass of Carbon in the Crude Iron used for Crude Steel Production – Mass of Carbon in the Crude Steel)*44 / 12 + Emission FactorEAF*Mass of Steel Produced in EAF

The Tier 1 method was used to calculate emitted indirect gases (NOx, NMVOC, CO and SO2) from steel processing.

b) Activity data

Mass of Carbon in Crude Iron, used for Crude Steel Production, was calculated through factory specific data. Similarly, while calculating Mass of Carbon in the Crude Steel, the factory specific values were taken into account. The relevant data is attached to the submission as confidential materials.
The aggregated data of produced steel from 2010 to 2013 are shown below in Table 4.19.

TABLE 4.19 AMOUNT OF PRODUCED STEEL IN GEORGIA FROM 2010 TO 2011

Steel Production	
Year	Activity Data* (t)
2010	104326
2011	156784
2012	207341
2013	251204

** Sum of data from Rustavi Metallurgy Plant and GeoSteel Factory*

The produced steel data was used for to calculate indirect emissions in accordance with the Revised IPCC 1996 Guidance.

c) Emission factors

The Emission Factor EAF, taken from the IPCC GPG 2000, equals 5kg CO2 per ton of steel produced, including trace admixtures possibly spread out in the atmosphere: NOx, NMVOCs, CO and SO2. The default emission factors are given by the same guidelines: 40, 30, 1 and 45 g of gas/ton of produced steel.

4.4.2. FERROALLOYS PRODUCTION

4.4.2.1. SOURCE-CATEGORY DESCRIPTION AND CALCULATED EMISSIONS

The ferroalloy plants produce enriched alloys, which are transmitted by the steel producing plants to manufacture steel alloy. Ferroalloys production includes the metallurgical reduction process, which causes significant CO_2 emissions.
The highest emissions from the source-category of Ferroalloys Production were calculated in 2012, at approximately 444 Gg of CO_2. Afterwards, emissions declined by 3 percent, and at the end of the counting period reached 431 Gg. The lowest value were in 2010, with about 346 Gg.
Emissions calculated, based on statistical data provided in this subsector and on the emission coefficients given in the methodological instructions of the IPCC 1996, are presented in Table 4.20.

TABLE 4.20. CO2 EMISSIONS (GG) FROM PRODUCTION OF THE SILICON-MANGANESE IN 2010-2013

Module		Industrial Processes		
Submodule		Metal Production		
Worksheet		2_11		
Sheet		4 OF 11 FERROALLOYS - TIER Ib - CO_2 EMISSIONS		
Step 4				
Year	A Amount of Ferroalloy Produced (t)	B Emission Factor (t CO_2/t Ferroalloy Produced)	C CO_2 Emitted (t)	D CO2 Emitted (Gg)
			C=(A*B)	D=C/10^3
2010	203791	1.7	346444.7000	346.4447
2011	242746	1.7	412668.2000	412.6682
2012	261074.5	1.7	443826.6500	443.8267
2013	253361.1	1.7	430713.8700	430.7139

4.4.2.2. METHODOLOGY

a) Method used

The Tier I approach of the IPCC 1996 was used to calculate emissions by multiplying the quantity of produced ferroalloys and typical emission factors.

b) Activity data

The National Statistics Office of Georgia (GEOSTAT) is the source for the ferroalloy production data. Only the silicon manganese production was performed, and to produce 1 ton of the silicon manganese, 30-40 kg of carbon electrodes was consumed, and 2.5 tonnes of 25-40% rich iron ore were processed. In total, 450-500 kg of reducer was consumed.

c) Emission factors

The default EF for silicon-manganese is 1.7 ton of CO_2/ton of produced silicon-manganese[33].

4.4.3. ALUMINUM PRODUCTION

This source category does not exist in Georgia.

4.4.4. OTHER METAL PRODUCTION

This source category does not exist in Georgia.

4.4.5. SF_6 USED IN ALUMINUM AND MAGNESIUM FOUNDRIES

This source category does not exist in Georgia.

4.5. OTHER PRODUCTION

This category includes the production of pulp and paper (2D1), and food and drinks (2D2). Processing of wood[34] is not conducted, at present, in Georgia. However, paper produced in the

[33] http://www.ipcc-nggip.iges.or.jp/public/gl/invs5b.html (page 2.29, Table.2-17)

[34] Here is foreseen the paper and cardboard production that was conducted in Zugdidi in past years

Tserovani Plant uses imported raw materials, and does not cause greenhouse gas emissions into the atmosphere.

4.5.1. FOOD AND DRINKS PRODUCTION

4.5.1.1. SOURCE–CATEGORY DESCRIPTION AND CALCULATED EMISSIONS

From the source category Food and Drinks Production, direct greenhouse gases are not produced, therefore, only indirect gases and NMVOCs were estimated. During the discussed period, different food industry enterprises functioned in Georgia, among them meat and fish processing, corn drying and milling, bakery, confectionary, sugar, wine, spirit, beer, soft drinks, dairy products, coffee roasting and milling. From this subcategory, only the non-methane volatile organic compounds emissions (NMVOCs) were calculated.

Emissions calculated on based on statistical data provided in this subsector, and on emission factors offered by the methodological instructions of IPCC 1996, are given in Table 4.21.

According to the conducted calculations, it is obvious that the amount of NMVOCs spread into the atmosphere from foods and drinks production on Georgia's territory during 2010-2013, are significant and exceed emissions from asphalt production by 200 times (see Table 4.21).

TABLE 4.21 NMVOCS EMISSIONS FROM THE FOOD AND DRINKS PRODUCTION IN 2010-2013 IN GEORGIA (GG)

Production	2010	2011	2012	2013
Food and Drink	2.55	2.13	2.04	2.14

In this sector, food production is NMVOCs emission major contributor, with approximately 98% of the total amount of emitted NMVOCs.

4.5.1.2. METHODOLOGY

a) Method used

It is recommended to calculate using Tier 2, which takes into consideration a production technology designed for each separate product. As for the Tier 3 approach, it foresees including the modeling into the calculation process. The Tier 2 approach was applied for calculations.

b) Activity data

The subsector of food and drinks production integrates the complete circle of food production: thermal processing of fats, baking, fermentation, cooking, drying, corn drying and milling processes. This is accompanied by emissions of different volatile compounds, among only the NMVOCs emissions according to the IPCC Methodological Guidelines will be discussed. In this sector, emissions from processing of dairy products or oils are not discussed, as their processing technologies do not require heating, and consequently emissions are not significant. In drinks (beer, wine, alcohol) production grapes, fruits and corn, are used, which should be matured before processing. During this process, starch is turned into sugar, and the sugar turns into ethyl spirit with participation of yeast microbes. This process is called fermentation. Occasionally, 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 emits most NMVOCs. In Table 4.22, data on the food production during 2010-2013 in Georgia, is provided.

TABLE 4.22 - FOOD PRODUCTS (TON) AND DRINKS (HL) PRODUCED IN GEORGIA IN 2010-2013

Product/Food and Drink	2010	2011	2012	2013
Meat and semi-prepared meat food (t)	9 987	15 353	20537	26492
Fish and fish product (t)	1 002	2 135	1373	1064
Margarine and similar products (t)	...	376	140	273
Drying and grinding of wheat (t)	401 500	480 482	488 460	440 589
Bread baking (t)	126 086	145 640	135 211	151 412
Confectionary (t)	7 684	16 539	17 553	18 974
Sugar (t)	74 161	C	C	C
Milling and roasting of coffee (t)	1 889	2 207	2 401	2 411
Forage for domestic animals (t)	3 207	3 446	5 628	6 720
Sparkling wine (hl)	114.2	138.8	123.7	164.5
White wine (hl)	2 476	2 905	4 499	6 552
Beer (hl)	14 286	15 499	18 029	21 208
Spirit, vodka (hl)	699	860	856	436
Brandy (hl)	828	1000	1230	1756

c) Emission factors

The emission coefficients offered in the IPCC Guidelines are provided in Table 4.23 and are calculated under the following assumptions:

- For producing 1 tonne beer, 0.15 ton of grains is consumed;
- Brandy fermentation is performed during 3 years, but other alcohol drinks do not require fermentation;
- It is considered that beer includes 4% of alcohol, if the mass of 1m^3 is 1 ton;
- Spirit includes 40% of alcohol;
- The density of the ethyl alcohol is 789 kg/m^3.

TABLE 4.23 COEFFICIENTS OF NMVOCS EMISSIONS FOR THE SUBCATEGORY "FOOD AND DRINKS PRODUCTION"[35]

Food	EF kg NMVOCs/t Food Production	Drinks	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	10.0	Beer	0.035

[35] http://www.ipcc-nggip.iges.or.jp/public/gl/invs5b.html (page 2.42, Table. 2-26)

products			
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		

4.6. PRODUCTION OF HALOCARBONS AND SULPHUR HEXAFLUORIDE

This source category does not exist in Georgia.

4.7. CONSUMPTION OF HALOCARBONS AND SULPHUR HEXAFLUORIDE

Nowadays, industrial gases (hydrofluorocarbons -HFCs, perfluorocarbons -PFCs and sulphur hexafluoride -SF_6) are imported only for utilization. Accordingly, emissions are specified only by their usage. Calculation of halocarbons is important as they are characterized by stability and high global warming potential (GWP). Currenty, neither the statistics deparment, nor customs service register PFCs in their data bases.

4.7.1. CONSUMPTION OF HALOGEN CARBON

4.7.1.1. METHODOLOGY

a) Method applied

According to the IPCC 2000 GPG, to estimate potential emissions, the Tier 1 method was used:

Potential emission = production + import – export

Where:
In Georgia, HFCs have not been produced yet. Subsequently, the production is zero. This applies to export as well. Accordingly, the emissions from the sub-sector of Consumption of Halocarbons corresponds to imported gases and equipment.

a) Activity data.

Since the most accurate data of imported goods are collected by customs service, the data of the HFC gases were collected from it. The aggregated values were separated in four different compounds: HFC-134a, HFC-125, HFC-143a, and HFC-32, by expert judgment.

c) Emission factors

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

4.7.1.2. CALCULATED EMISSIONS

The potential emissions from f-gases in Refrigerators and Air-conditioners are represented in Table 4.24 below.

TABLE 4.24. HFC POTENTIAL EMISSIONS IN GEORGIA IN 2010-2013

Gases	Quantity of Pollutant (kg)	GWP	CO_2 eq. (Gg)
HFC-134a			
2010	21 500	1300	27.95
2011	58 400	1300	75.92
2012	85 500	1300	111.15
2013	54 500	1300	70.85
HFC-125			
2010	18 500	2800	51.8
2011	32 500	2800	91
2012	54 500	2800	152.6
2013	34 000	2800	95.2
HFC-143a			
2010	14 000	3800	53.2
2011	15 600	3800	59.28
2012	17 000	3800	64.6
2013	6 000	3800	22.8
HFC-32			
2010	7 000	650	4.55
2011	18 500	650	12.025
2012	40 000	650	26
2013	29 500	650	19.175

4.7.2. SF_6 EMISSIONS FROM APPLIANCES

In Georgia, during the reporting period, only SF6 equipment operated. At energy facilities, SF6 is used in communication equipment. According to official information provided by the State Electricity specialists, this started from 1997 in different voltage breakers. Currently, existing Elegas Breakers' are used by JSC GSE and consists of 304 suites, while the sum number of SF6 is 5 771.1 kg. The type of used breakers is hermetic and their operation term is 30-40 years. It should be noted, that according to experts' reports in recent years, quality (hermetization) of this type of equipment has significantly improved, which, subsequently, reduced (50-90%) SF6 emissions from electric utilities. Statistics of installed SF6 breakers in JSC "Georgian State Electro system" from 2010-2013 are given in Table 4.25.

TABLE 4.25. INSTALLED STATE ELECTRICITY SYSTEM'S AMOUNT OF BREAKERS CONTAINING SF6 IN 2010-2013

Year	2010	2011	2012	2013	**Total**
Amount	85	31	14	1	131

Amount of SF_6 released during the working processes of electrical equipment was calculated for 1997-2013 in Georgia. The results of calculations are presented in Table 4.26.

TABLE 4.26 SF6 QUANTITIES RELEASED FROM ELECTRICAL EQUIPMENT IN GEORGIA IN 2010-2013

Year	Consumed SF_6, tonnes	Rate of SF_6 losses	SF_6 Emission, Tonnes	SF_6 Emission, Gg	SF_6 Emission in Gg CO_2eq
2010	4.6704	0.002	0.00934	0.00000934	0.223226
2011	5.2740	0.002	0.01055	0.00001055	0.252145
2012	5.7480	0.002	0.01150	0.00001150	0.27485
2013	5.7711	0.002	0.01154	0.00001154	0.275806

Calculations show, that from the used equipment, SF_6 emission is practically insignificant in Georgia's energy system. It reached a maximum in 2013, amounting to 0.000012 Gg or 0.276 Gg CO_{2eq}.

To calculate SF_6 emissions, the IPCC 2006 method was used, since regional spreading coefficients wereprovided for, and types of devices (airproof, closed). This data is provided in Table 4.27.

TABLE 4.27 THE COEFFICIENTS OF SF6 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**

5. SOLVENTS AND OTHER PRODUCTS USE

5.1. SECTOR REVIEW AND CALCULATED EMISSIONS

In general, one of the major sources of greenhouse gas emissions are 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.
The total emissions from subsector "Solvent and other product use" are given in Table 5.1

TABLE 5.1. TOTAL EMISSIONS OF N_2O FROM SUBSECTOR "SOLVENT AND OTHER PRODUCT USE"

Year	2010	2011	2012	2013
N_2O from healthcare sector (Gg)	0.00003	0.00003	0.00003	0.00004

Average annual emissions of N_2O used for anesthesia in medicine during the discussed period, amounted to 0.00003 Gg/year, or a slightly smaller size.

Other (4D). N_2O emissions in 2010-2013 were estimated in this subsector for anesthesia in the medical field. Nitrogen monoxide (N_2O) emissions are released in different ways (agriculture, industry, transport) and one of the fields, which also contributes to the emission of nitric oxide in medicine.
Nitrogen monoxide-containing substances are most actively used during anesthesia in the medical sector. In addition, most inhalational anesthetics contain N_2O.

TABLE 5.2. EMISSION OF N2O FROM THE SUBSECTOR "SOLVENTS AND OTHER PRODUCT USE" IN 2010-2013

Year	Number of Medical Operations Conducted	EF (kg N_2O /per capita)	N_2O Emission (Gg)
2010	134 941	$0.196*10^{-3}$	0.00003
2011	143 262	$0.196*10^{-3}$	0.00003
2012	165 679	$0.196*10^{-3}$	0.00003
2013	189 478	$0.196*10^{-3}$	0.00004

5.2. METHODOLOGY

a) Method used

Calculations were based on the assumption that N_2O used for anesthesia is emitted in the atmosphere as a whole, or emission of N_2O is equal to its use.

It was also assumed that consumed N_2O is proportional to the total number of surgical operations in the country. The data and results of the calculations are presented in Table 5.3.

b) Activity data

Surgery visits from 2010-2013 in Georgia were used for the calculation, which were provided by the Ministry of Health and Social Security, and National Statistics Office of Georgia. The number of medical operations are represented in Table 5.3.

TABLE 5.3. ACTIVITY DATA ON SURGERIES CARRIED OUT IN GEORGIA IN 2010-2013

Year	Number of medical operations conducted
2010	134 941
2011	143 262
2012	165 679
2013	189 478

c) Emission Factor

The emission factor is $0.196*10^{-3}$kg[36].

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

6. AGRICULTURE

6.1. SECTOR OVERVIEW

Georgia's agriculture sector, as source of GHG emissions, comprises of four subcategories: Enteric Fermentation, Manure Management, Agricultural Soils, and Field Burning of Agricultural Residues.

The other IPCC subcategories, such a rice cultivation and prescribed burning of savannas are not specific, and 'other', are not specific for Georgia and are not considered. Manure Management refers to all emissions from Animal Waste Management Systems (AWMS), in particular from anaerobic lagoons, liquid systems, solid storage and drylot, 'used for fuel' and 'other systems'. Emissions from daily spread and animal waste dropped on the soil during grazing on grasslands (pasture range and paddock) are reported under subcategory agricultural soils.

GHG emissions from the agricultural sector are summarized in Tables 6.1-6.3. These clearly show that methane (CH_4) emissions from enteric fermentation are the largest source of methane within this sector, while agriculture soils are the largest source of nitrous oxide (N_2O).

In Table 6.1, methane emissions from the agriculturee sector, from the Third National Communications (TNC) of Georgia to the UNFCCC over the past several years, are presented. According to this Table, the difference between results received in TNC and BUR for 2010 and 2011 constitutes, accordingly, 2.5% and 6.6%. Among the categories, a more significant difference can be seen in Manure Management. In previous inventories, cows were all attributed to dairy cattle. However, according to agriculture experts, most of Georgia's cows present a mix of breeds with a low or moderate size and productivity. Regarding N_2O emissions, a difference between the inventories is less than 2% (see Table 6.2). The differences are mainly the result of more precise data on N fertilizers.

TABLE 6.1: METHANE EMISSIONS FROM THE AGRICULTURE SECTOR (GG)

Gas/Source	1990	1994	2000	2005	2010	2011	2012	2013
CH_4 / Enteric Fermentation (BUR)					58.42	57.79	60.88	64.33
CH_4 / Enteric Fermentation (TNC)	*79.22*	*46.07*	*54.09*	*60.33*	*54.94*	*56.64*		
Difference, in %					*6.3*	*2.0*		
CH_4 / Manure Management (BUR)					4.75	4.53	4.99	5.63
CH_4 / Manure Management (TNC)	*14.71*	*9.86*	*12.40*	*14.19*	*9.88*	*10.17*		
Difference, in %					*-51.9*	*-55.5*		
CH_4 / Field Burning of Agricultural Residues (BUR)					0.17	0.29	0.27	0.35
CH_4 Field Burning of Agricultural Residues (TNC)	*0.45*	*0.27*	*0.25*	*0.44*	*0.12*	*0.21*		
Difference, in %					*41.7*	*38.1*		

CH4 total in Gg (BUR)					**63.33**	**62.61**	**66.14**	**70.31**
CH4 total in Gg (TNC)	***94.38***	***56.20***	***66.74***	***74.96***	***64.94***	***67.02***		
Difference, in %					***-2.5***	***-6.6***		

TABLE 6.2: NITROUS OXIDE EMISSIONS FROM THE AGRICULTURE SECTOR IN GG

Gas/Source	1990	1994	2000	2005	2010	2011	2012	2013
Manure Management (BUR)					0.41	0.40	0.43	0.49
Manure Management (TNC)	*0.52*	*0.23*	*0.23*	*0.27*	*0.15*	*0.14*		
Difference, in %					*175.2*	*179.7*		
Agricultural Soils (BUR)					3.04	2.94	3.15	3.55
Agricultural Soils (TNC)	*5.12*	*3.35*	*2.30*	*3.18*	*3.36*	*3.22*		
Difference, in %					*-9.5*	*-8.6*		
Direct Soil Emissions (BUR)					1.82	1.78	1.9	*2.14*
Direct Soil Emissions (TNC)	*2.92*	*2.14*	*2.30*	*3.18*	*2.01*	*1.95*		
Difference, in %					*-9.4*	*-8.6*		
Synthetic Fertilizers (BUR)					0.31	0.26	0.30	0.39
Synthetic Fertilizers (TNC)	*0.55*	*0.68*	*0.83*	*1.35*	*0.89*	*0.77*		
Difference, in %					*-65.1*	*-66.0*		
Animal Waste Applied to Soils (BUR)					0.38	0.36	0.40	0.44
Animal Waste Applied to Soils (TNC)	*0.55*	*0.29*	*0.32*	*0.37*	*0.24*	*0.24*		
Difference, in %					*61.0*	*48.8*		
Crop Residue Decomposition (BUR)					0.06	0.11	0.11	0.13
Crop Residue Decomposition (TNC)	*0.36*	*0.31*	*0.28*	*0.43*	*0.11*	*0.17*		
Difference, in %					*-47.4*	*-36.8*		
Pasture Range and Paddock (BUR)					1.07	1.04	1.10	1.18
Pasture Range and Paddock (TNC)	*1.46*	*0.86*	*0.87*	*1.03*	*0.77*	*0.77*		
Difference, in %					*38.6*	*35.6*		
Indirect Emissions (BUR)					1.22	1.16	1.25	*1.41*
Indirect Emissions (TNC)	*2.20*	*1.21*	*0.00*	*0.00*	*1.35*	*1.27*		
Difference, in %					*-9.6*	*-8.4*		
Atmospheric Deposition (BUR)					0.24	0.23	0.24	0.27
Atmospheric Deposition (TNC)	*0.39*	*0.22*	0,25	0,30	*0.22*	*0.21*		
Difference, in %					*8.6*	*8.0*		

Gas/Source	1990	1994	2000	2005	2010	2011	2012	2013
Nitrogen Leaching & Run Off (BUR)					0.99	0.94	1.01	1.14
Nitrogen Leaching & Run Off (TNC)	*1.81*	*0.99*	1,21	1,56	*1.13*	*1.05*		
Difference, in %					*-12.2*	*-10.8*		
Field Burning of Agricultural Residues (BUR)					0.01	0.01	0.01	0.01
Field Burning of Agricultural Residues (TNC)	*0.01*	*0.01*	*0.01*	*0.01*	*0.002*	*0.004*		
Difference, in %					*400*	*150*		
N_2O total (BUR)					**3.46**	**3.35**	**3.59**	**4.05**
N_2O total in Gg (TNC)	***5.65***	***3.59***	***2.54***	***3.46***	***3.51***	***3.36***		
Difference, in %					*-1.4*	*-0.4*		

TABLE 6.3: GHG EMISSIONS FROM THE AGRICULTURE SECTOR IN Gg CO_2EQ

Gas/Source	1990	1994	2000	2005	2010	2011	2012	2013
CH_4								
Enteric Fermentation (BUR)					1,227	1,214	1,278	1,351
Enteric Fermentation (TNC)	*1,664*	*967*	*1,136*	*1,267*	*1,154*	*1,189*		
Manure Management (BUR)					100	95	105	118
Manure Management (TNC)	*309*	*207*	*260*	*298*	*207*	*214*		
Field Burning of Agricultural Residues (BUR)					4	6	6	7
Field Burning of Agricultural Residues (TNC)	*9*	*6*	*5*	*9*	*3*	*4*		
CH_4 total in GgCO_2eq (BUR)					**1,330**	**1,315**	**1,389**	**1,477**
CH_4 total in GgCO_2eq (TNC)	***1,982***	***1,180***	***1,401***	***1,574***	***1,364***	***1,407***		
N_2O								
Manure Management (BUR)					127	124	133	152
Manure Management (TNC)	*161*	*71*	*71*	*84*	*46*	*44*		
Agricultural Soils (BUR)					942	911	977	1,101
Agricultural Soils (TNC)	*1,587*	*1,039*	*1,166*	*1,562*	*1,041*	*997*		
Direct Soil Emissions (BUR)					564	552	589	663
Direct Soil Emissions (TNC)	*905*	*663*	*713*	*986*	*623*	*604*		
Synthetic Fertilizers (BUR)					96	81	93	121
Synthetic Fertilizers (TNC)	*171*	*211*	*257*	*419*	*275*	*237*		
Animal Waste Applied to Soils (BUR)					118	112	124	136

Gas/Source	1990	1994	2000	2005	2010	2011	2012	2013
Animal Waste Applied to Soils (TNC)	*171*	*90*	*99*	*115*	*73*	*75*		
Crop Residue Decomposition (BUR)					19	34	34	40
Crop Residue Decomposition (TNC)	*112*	*96*	*87*	*133*	*35*	*54*		
Pasture Range and Paddock (BUR)					332	322	341	366
Pasture Range and Paddock (TNC)	*453*	*267*	*270*	*319*	*239*	*238*		
Indirect Emissions (BUR)					378	360	388	437
Indirect Emissions (TNC)	682	375	453	577	418	393		
Atmospheric Deposition (BUR)					74	71	74	84
Atmospheric Deposition (TNC)	*121*	*68*	*78*	*93*	*69*	*66*		
Nitrogen Leaching & Run Off (BUR)					307	291	313	353
Nitrogen Leaching & Run Off (TNC)	*561*	*307*	*375*	*484*	*350*	*327*		
Field Burning of Agricultural Residues (BUR)					3	3	3	3
Field Burning of Agricult. Residues (TNC)	*3*	*3*	*3*	*3*	*1*	*1*		
N_2O total in $GgCO_2eq$ (BUR)					**1,073**	**1,039**	**1,113**	**1,256**
N_2O total in $GgCO_2eq$ (TNC)	***1,752***	***1,113***	***1,240***	***1,649***	***1,088***	***1,042***		
Total in $GgCO_2eq$ (BUR)					**2,403**	**2,353**	**2,502**	**2,732**
Total in $GgCO_2eq$ (TNC)	***3,733***	***2,096***	***2,394***	***2,940***	***2,452***	***2,450***		
Difference, in %					***-2.0***	***-3.9***		

The share of gases in the agriculture sector - emissions as well as share of sub-categories emissions - are presented in table 6.4. According to this Table, the share of methane varies within 54.0–55.9 percent and the share of nitrous oxide within 44.1-46.0 percent. The largest source is enteric fermentation.

TABLE 6.4: SHARE OF SUB-CATEGORIES EMISSIONS IN AGRICULTURE SECTOR EMISSIONS

Source	2010	2011	2012	2013
Enteric Fermentation	51.0	51.6	51.1	49.4
Manure Management	4.1	4.0	4.2	4.3
Field Burning of Agricultural Residues	0.1	0.3	0.2	0.3
Total CH_4	**55.3**	**55.9**	**55.5**	**54.0**
Manure Management	5.3	5.2	5.4	5.5
Agricultural Soils	39.2	38.8	39.0	40.3
Direct Soil Emissions	23.5	23.4	23.5	24.3
Synthetic Fertilizers	*3.9*	*3.5*	*3.7*	*4.5*
Animal Waste Applied to Soils	*4.9*	*4.8*	*4.9*	*5.0*

Crop Residue Decomposition	*0.8*	*1.4*	*1.3*	*1.4*
Pasture Range and Paddock	*13.8*	*13.8*	*13.6*	*13.4*
Indirect Emissions	15.8	15.3	15.5	16.0
Atmospheric Deposition	*3.0*	*3.0*	*3.0*	*3.1*
Nitrogen Leaching & Run Off	*12.7*	*12.3*	*12.5*	*13.0*
Field Burning of Agricultural Residues	0.1	0.1	0.1	0.1
Total N_2O	**44.7**	**44.1**	**44.5**	**46.0**
Agriculture total	**100.0**	**100.0**	**100.0**	**100.0**

The share of agriculture sector emissions, as well as the share of sub-categories emissions in national GHG emissions in 2010-2013, is presented in Table 6.5.

TABLE 6.5: SHARE OF AGRICULTURE SECTOR EMISSIONS AND SHARE OF SUB-CATEGORIES EMISSIONS IN NATIONAL GHG EMISSIONS IN 2010-2013

Source	2010	2011	2012	2013
Enteric Fermentation	9.5	7.6	7.4	8.1
Manure Management	0.8	0.6	0.6	0.7
Field Burning of Agricultural Residues	0.03	0.04	0.03	0.04
Total CH_4	10.3	8.2	8.1	8.9
Manure Management	1.0	0.8	0.8	0.9
Agricultural Soils	7.3	5.7	5.7	6.6
Direct Soil Emissions	4.4	3.4	3.4	4.0
Synthetic Fertilizers	0.7	0.5	0.5	0.7
Animal Waste Applied to Soils	0.9	0.7	0.7	0.8
Crop Residue Decomposition	0.1	0.2	0.2	0.2
Pasture Range and Paddock	2.6	2.0	2.0	2.2
Indirect Emissions	2.9	2.2	2.3	2.6
Atmospheric Deposition	0.6	0.4	0.4	0.5
Nitrogen Leaching & Run Off	2.4	1.8	1.8	2.1
Field Burning of Agricultural Residues	0.02	0.02	0.02	0.02
Total N_2O	**8.3**	**6.5**	**6.5**	**7.5**
Agriculture total	18.6	14.7	14.5	16.4

6.2. ENTERIC FERMENTATION

The emissions source category Enteric Fermentation consists of the sub-sources: cattle, buffalos, sheep, goats and swine. Horses and mules are not considered due to the absence of data. Camels and asses are not specific for Georgia. During 2010-2013, GHG emissions varied mainly as a result of livestock population variations.

The major Key Source is enteric fermentation by cattle, which contributes about 90% of the total emissions from enteric fermentation.

Tier 1

Methodology: To estimate methane emissions for the source category enteric fermentation, the IPCC 1996 methodology is used. The amount of methane emitted by a population of animals is calculated by multiplying the emission rate per animal by the number of animals [IPCC 1996, Reference Manual, p. 4.6].

$$EM_i = EF_i \bullet Pop_i$$

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: Quarterly data on livestock population are used (sourced from the website of National Statistic Office of Georgia). As livestock population significantly decreased by the end of each year, applying early data (population by end of yaer) will lead tounderestimated values. The number of animals for 2010-2013 is given in Table 6.6. For demonstration purposes, see also cattle population during 2010-2013 presented in Fig.6.1 and in Annex 1.

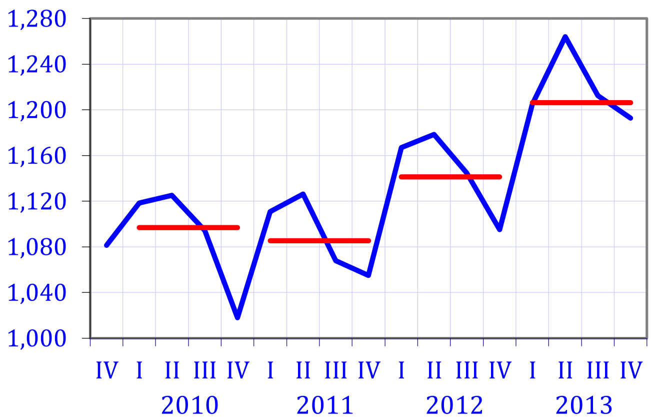


FIG.6.1: ESTIMATED NUMBER OF CATTLE IN THOUSANDS (RED COLORED LINE) BASED ON QUARTERLY DATA

TABLE 6.6: THE NUMBER OF ANIMALS (THOUSAND HEADS) IN 2010-2013

Animal category	2010	2011	2012	2013
Cattle	1,097	1,085	1,141	1,206
Buffalos	34	34	35	37
Sheep	721	694	754	874

Animal category	2010	2011	2012	2013
Goats	71	65	61	67
Swine	168	127	191	288
Poultry	8,230	7,681	8,156	8,081

The prevailing native breeds of cattle in Georgia are Georgian Mountain (Highlander) and Red Mingrelian. The Georgian Mountain and Red Mingrelian are late maturing and are endowed with 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 difffers slightly (by 3-4%). Consequently, the average value of emission factors was used, considering three breeds: Early maturing (average), Georgian Mountain and Red Mingrelian. The cattle distribution by breeds in 2010-2013 is based on expert judgments.

TABLE 6.7: CATTLE DISTRIBUTION BY BREEDS (IN THOUSAND HEADS)

year	Breed			Total
	Early Maturing	Georgian Mountain	Red Mingrelian	
2010	219	439	439	1,097
2011	217	434	434	1,085
2012	228	457	457	1,142
2013	241	483	483	1,207

Emission factors: Emission factors for late maturing cattle were taken according to default values for the Asia region, as the characteristics for this type of animals are most of all suitable to Georgian conditions. In particular, cattle mainly are fed in pastures or kept stalled; animals are relatively small in size, and have a multi-purpose application. For Early Maturing cattle, the default values of the Eastern European region are used [IPCC 1996, Reference Manual, p. 4.11, Table 4.4]. For other types of animals, emission factors are taken according to default values for developing countries with a temperate climate [IPCC 1996, Reference Manual, p. 4.10, Table 4.3]. CH_4 emission factors for livestock categories are presented in Table 6.8.

Emissions: Methane emissions from enteric fermentation for animal categories are presented in Table 6.8.

TABLE 6.8: METHANE EMISSION FACTORS AND EMISSIONS FROM ENTERIC FERMENTATION (TIER 1)

Animal category	Population, thousand heads				Emission Factor, $kgCH_4$/head	Emission, $GgCH_4$			
	2010	2011	2012	2013		2010	2011	2012	2013
Late Maturing Cattle	878	868	913	965	44	38.61	38.20	40.17	42.46
Early Maturing Cattle	219	217	228	241	56	12.28	12.16	12.78	13.51
Buffalos	34	34	35	37	55	1.86	1.85	1.94	2.05

Animal category	Population, thousand heads				Emission Factor, $kgCH_4$/head	Emission, $GgCH_4$			
	2010	2011	2012	2013		2010	2011	2012	2013
Sheep	721	694	754	874	5	3.61	3.47	3.77	4.37
Goats	71	65	61	67	5	0.35	0.32	0.30	0.34
Swine	168	127	191	288	1	0.17	0.13	0.19	0.29
Total						**56.88**	**56.13**	**59.15**	**63.02**
Total in GgCO2eq						**1,213**	**1,197**	**1,261**	**1,343**

Tier 2

According to the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (farther referred as IPCC GPG), if enteric fermentation is a key source category, the Tier 2 approach should be used for the animal categories which represent a large portion of the country's total emissions. In 2010-2013, methane emissions from cattle constituted about 90% of total methane emissions from enteric fermentation (see Table 6.10). Consequently. Tier 2 was used for this category.

TABLE 6.9: SHARE OF ANIMAL CATEGORY IN METHANE EMISSIONS FROM ENTERIC FERMENTATION (%)

Category	2010	2011	2012	2013
Late Maturing Cattle	67.9	68.1	67.9	67.4
Early Maturing Cattle	21.6	21.7	21.6	21.4
Buffalos	3.3	3.3	3.3	3.3
Sheep	6.3	6.2	6.4	6.9
Goats	0.6	0.6	0.5	0.5
Swine	0.3	0.2	0.3	0.5
Total	100.0	100.0	100.0	100.0

Methodology: Tier 2 is a more complicated approach, which requires detailed characteristics of cattle (breed, age, weight, milk production, birth and etc.). The emission factor for each selected animal category (type) was assessed based on this data. Afterwards, emissions were calculated for each group of cattle, by multiplying a population of cattle (grouping is made according to breed and age) with the corresponding emission factor and by summing up the calculated emissions.

Activity data: Methane emissions from enteric fermentation in cattle depends on cattle characteristics. Due to this difference, a model was developed which classifies cattle by age. Scientific information from experts in zoological veterinary was used. The modelling was performed separately for early maturing and late maturing breeds, as their growth characteristics are different. The model parameters were selected based on the following information:

1. Early maturing cattle have their first calf at three. When they are five, the cattle is considered to be mature. Late maturing cattle deliver their first calf at four, and are considered mature when they are six. The cattle's average lifetime is fifteen on average;
2. A cow's gestation period lasts nine months, lactation period twelve months, and dry period two months;
3. The ratio female to male equals to 50:50. According to cattle genetics, generally similar in all animals, the sex heredity is equal;
4. In Georgia, the consumption of calf veal is traditionally high, as a result the slaughter percentage is, correspondingly, higher;

From year to year, the percentage structure of cattle age changed in accordance with items 1-4. This is, as such, reflected in the model by not breaking the number of cattle balance for a given year, or from year to year

Emission factors: emission factors for this category were calculated as described in the IPCC GPG- Tier 2 approach, according to the following formula:

$$EF = (GE \bullet Y_m \bullet 365 \text{ day/year}) / (55.65 \text{ mg/kg}CH_4),$$

$$GE=\{[(NE_m+NE_{MOBILISED}+NE_a+NE_l+NE_w + NE_p) / (NE_{ma}/DE)] + [(NE_g) / (NE_{ga} /DE)]\} / (DE / 100),$$

$$NE_{ma}/DE =1.123-(4.092 \bullet 10^{-3} \bullet DE) + [1.126 \bullet 10^{-5} \bullet (DE)^2]-(25.4/DE),$$

$$NE_g = 4.18 \bullet \{0.0635 \bullet [0.891 \bullet (BW \bullet 0.96) \bullet (478/(C \bullet MW))]^{0.75} \bullet (WG \bullet 0.92)^{1.097}\},$$

$$NE_{ga}/DE = 1.164 - (5.160 \bullet 10^{-3} \bullet DE) + [1.308 \bullet 10^{-5} \bullet (DE)^2] - (37.4/DE),$$

Where:

NE_m — Net energy for maintenance (MJ/day). $NE_m = Cf_i \bullet (weight)0^{.75}$. Cf_i=0.322 for non-lactating cattle and Cf_i =0.335 for lactating cattle (IPCC GPG - tTble 4.4).

$NE_{MOBILISED}$ — Net energy due to weight loss (MJ/day). $Re_{mobilized}$ = 19.7•Weight Loss. Weight Loss = animal weight lost per day (kg/day)

NE_a — Net energy for animal activity (MJ/day). $NE_a = C_a \bullet NE_m$. C_a coefficient corresponds to animal feeding conditions. In Georgia cattle usually grazes on pastures and hilly areas hence wasting much of the energy in feeding. According to IPCC GPG (Table 4.5) in these conditions C_a=0.36 (for animal gain is recommended C_a =0.17).

NE_l — Net energy for lactation (MJ/day). NE_l=daily milk amount• (1.47+0.40• fattiness). Daily milk amount is the same as daily milk production. Fattiness is meant to be fattiness of milk (%)

NE_w — Net energy for work, MJ/day. $NE_w = 0.10 \bullet NE_m \bullet$hours of work per day. It was assumed that bulls are working for 1 hour per day.

NE_p — Net energy required for pregnancy (MJ/day). $NE_p = C_{pregnancy} \bullet NE_m$. $C_{pregnancy}$ is pregnancy coefficient. For cattle $C_{pregnancy}$ =0.1 (IPCC GPG, Table 4.7).

NE_{ma}/DE	Ratio of net energy available in a diet for maintenance to digestible energy consumed. DE = digestible energy expressed as a percentage of gross energy. Default value DE =60% (IPCC 1996, p. 4.31, Table A-1).
NE_g	Net energy required for growth (MJ/Day). C=0.8 for cows and C=1.2 for bulls (IPCC GPG, p. 4.15). BW body mass of mature animal (kg), WG daily weight gain (kg/day).
NE_{ga}/DE	Ratio of net energy available for growth in a diet to digestible energy consumed.
Y_m	Methane conversion rate which is the fraction of gross energy in feed converted to methane. Y_m =0.06 for cows and their gain and Y_m =0,07 for other cattle (IPCC GPG – Table 6.8).

Necessary data for calculations is given in Tables 6.10-6.12

TABLE 6.10: 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 6.11: 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 6.12: 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

Emissions: The calculation of emissions from the slaughtered cattle (estimating emissions from the start of the considered year, up to slaughtering) is based on the following rough assumption: the slaughter took place on average in the middle of the year, and the emission factor for the slaughtered cattle is equal to half of the emission factor for that year. The estimated emissions from cattle are given in Tables 6.13-6.15.

TABLE 6.13: ESTIMATED METHANE EMISSION FACTORS AND EMISSIONS FROM CATTLE (GEORGIAN MOUNTAIN BREED)

Cattle category	Age,	Population, thousand heads				Emission Factor, $kgCH_4$/head	Emissions, $GgCH_4$			
	year	2010	2011	2012	2013		2010	2011	2012	2013
Calf – Females	0-1	46.1	44.4	44.2	53.8	13	0.60	0.58	0.57	0.70
Heifer	1-2	37.1	38.7	39.6	41.7	29	1.07	1.12	1.15	1.21
Heifer	2-3	34.5	34.6	38.4	37.2	34	1.17	1.18	1.30	1.27
Heifer	3-4	35.3	32.1	34.6	36.4	34	1.20	1.09	1.18	1.24
Cow	4-5	16.1	16.0	15.4	15.7	37	0.60	0.59	0.57	0.58
Lactating Cow	4-5	17.5	17.3	16.7	17.0	52	0.91	0.90	0.87	0.89
Cow	5-6	17.6	15.2	15.8	14.8	38	0.67	0.58	0.60	0.56
Lactating Cow	5-6	19.0	16.5	17.1	16.0	53	1.01	0.87	0.91	0.85
Cow	>6	110.3	113.6	119.6	126.0	37	4.08	4.20	4.42	4.66
Lactating Cow	>6	54.3	55.9	58.9	62.1	53	2.88	2.97	3.12	3.29
Calf – Males	0-1	13.4	13.6	16.3	16.6	13	0.17	0.18	0.21	0.22
Bullock	1-2	13.4	11.5	12.9	14.6	36	0.48	0.41	0.47	0.52
Bullock	2-3	11.2	10.3	10.8	11.7	45	0.50	0.46	0.49	0.53
Bullock	3-4	5.6	4.9	7.1	9.7	49	0.27	0.24	0.35	0.48
Bull (castrate)	4-5	2.6	4.5	4.6	4.0	56	0.14	0.25	0.26	0.23
Bull (castrate)	5-6	2.2	2.1	2.5	3.2	55	0.12	0.11	0.14	0.18
Bull (castrate)	>6	2.6	2.9	2.1	2.0	55	0.14	0.16	0.11	0.11
Total		**438.7**	**434.1**	**456.5**	**482.5**		**16.03**	**15.90**	**16.72**	**17.50**

TABLE 6.14: ESTIMATED METHANE EMISSION FACTORS AND EMISSIONS FROM CATTLE (RED MINGRELIAN BREED)

Cattle category	Age,	Population, thousand heads				Emission Factor, $kgCH_4$/head	Emissions, $GgCH_4$			
	year	2010	2011	2012	2013		2010	2011	2012	2013
Calf – Females	0-1	46.1	44.4	44.2	53.8	16	0.74	0.71	0.71	0.86
Heifer	1-2	37.1	38.7	39.6	41.7	40	1.48	1.55	1.58	1.67
Heifer	2-3	34.5	34.6	38.4	37.2	43	1.48	1.49	1.65	1.60
Heifer	3-4	35.3	32.1	34.6	36.4	44	1.55	1.41	1.52	1.60
Cow	4-5	16.1	16.0	15.4	15.7	49	0.79	0.78	0.76	0.77
Lactating Cow	4-5	17.5	17.3	16.7	17.0	61	1.07	1.06	1.02	1.04
Cow	5-6	17.6	15.2	15.8	14.8	50	0.88	0.76	0.79	0.74

Cattle category	Age, year	Population, thousand heads				Emission Factor, $kgCH_4$/head	Emissions, $GgCH_4$			
		2010	2011	2012	2013		2010	2011	2012	2013
Lactating Cow	5-6	19.0	16.5	17.1	16.0	66	1.26	1.09	1.13	1.05
Cow	>6	110.3	113.6	119.6	126.0	49	5.40	5.57	5.86	6.17
Lactating Cow	>6	54.3	55.9	58.9	62.1	65	3.53	3.64	3.83	4.03
Calf – Males	0-1	13.4	13.6	16.3	16.6	17	0.23	0.23	0.28	0.28
Bullock	1-2	13.4	11.5	12.9	14.6	53	0.71	0.61	0.68	0.77
Bullock	2-3	11.2	10.3	10.8	11.7	63	0.71	0.65	0.68	0.74
Bullock	3-4	5.6	4.9	7.1	9.7	71	0.40	0.35	0.50	0.69
Bull (castrate)	4-5	2.6	4.5	4.6	4.0	76	0.20	0.34	0.35	0.31
Bull (castrate)	5-6	2.2	2.1	2.5	3.2	75	0.16	0.15	0.19	0.24
Bull (castrate)	>6	2.6	2.9	2.1	2.0	65	0.17	0.19	0.14	0.13
Total		**438.7**	**434.1**	**456.5**	**482.5**		**20.75**	**20.57**	**21.66**	**22.70**

TABLE 6.15: ESTIMATED METHANE EMISSION FACTORS AND EMISSIONS FROM CATTLE (EARLY MATURING BREEDS)

Cattle category	Age, year	Population, thousand heads				Emission Factor, $kgCH_4$/head	Emissions, $GgCH_4$			
		2010	2011	2012	2013		2010	2011	2012	2013
Calf – f=Females	0-1	29.1	28.4	29.8	32.6	28	0.81	0.79	0.83	0.91
Heifer	1-2	27.2	26.1	27.5	28.5	70	1.90	1.83	1.93	2.00
Heifer	2-3	25.2	23.9	25.0	25.9	70	1.76	1.67	1.75	1.81
Cow	3-4	10.9	10.6	11.3	10.2	74	0.80	0.78	0.84	0.75
Lactating Cow	3-4	11.8	11.4	12.2	11.0	90	1.06	1.03	1.10	0.99
Cow	4-5	10.9	10.3	10.4	10.8	77	0.84	0.79	0.80	0.83
Lactating Cow	4-5	11.8	11.1	11.3	11.7	94	1.11	1.05	1.06	1.10
Cow	>5	48.4	49.5	51.3	55.0	74	3.58	3.66	3.79	4.07
Lactating Cow	>5	23.8	24.4	25.2	27.1	94	2.24	2.29	2.37	2.55
Calf – Males	0-1	6.9	6.6	8.1	10.5	30	0.21	0.20	0.24	0.32
Bullock	1-2	5.2	5.8	6.0	7.3	85	0.44	0.49	0.51	0.62
Bullock	2-3	4.5	4.7	5.6	5.5	101	0.46	0.48	0.57	0.55
Bull (castrate)	3-4	1.5	1.6	1.7	2.6	112	0.17	0.18	0.19	0.29
Bull (castrate)	4-5	1.1	1.4	1.5	1.4	114	0.12	0.16	0.17	0.16
Bull (castrate	>5	1.3	1.2	1.3	1.2	111	0.14	0.14	0.14	0.13

Cattle category	Age, year	Population, thousand heads				Emission Factor, $kgCH_4$/head	Emissions, $GgCH_4$			
		2010	2011	2012	2013		2010	2011	2012	2013
Total		**219.4**	**217.1**	**228.3**	**241.3**		**15.64**	**15.55**	**16.30**	**17.09**

Methane emissions from enteric fermentation in cattle estimated by the tier 2 approach are presented in the summarizing Table 6.16.

TABLE 6.16: METHANE EMISSIONS FROM ENTERIC FERMENTATION IN CATTLE (TIER 2)

Breed	Methane Emissions			
	2010	2011	2012	2013
Early Maturing	15.64	15.55	16.30	17.09
Georgian Mountain	16.03	15.90	16.72	17.50
Red Mingrelian	20.75	20.57	21.66	22.70
Total, $GgCH_4$	52.42	52.02	54.67	57.29
Total, $GgCO_2$eq	**1,101**	**1,092**	**1,148**	**1,203**

TABLE 6.17: METHANE EMISSIONS FROM ENTERIC FERMENTATION (TIER 2)

Livestock	Methane Emissions			
	2010	2011	2012	2013
Cattle	52.42	52.02	54.67	57.29
Buffalo	1.86	1.85	1.94	2.05
Sheep	3.61	3.47	3.77	4.37
Goats	0.35	0.32	0.30	0.34
Swine	0.17	0.13	0.19	0.29
Total in $GgCH_4$	**58.42**	**57.79**	**60.88**	**64.33**
Total in $GgCO_2$eq	**1,227**	**1,214**	**1,278**	**1,351**

Methane emissions, estimated applying tier 1 and tier 2 approaches, were compared. The results are presented in Table 6.18. According to this Table, the tier 2 approach leads to insignificantly more emissions than tier 1.

TABLE 6.18: COMPARISON OF ESTIMATED METHANE EMISSIONS PER TIER 1 AND TIER 2 APPROACHES

			2010	2011	2012	2013
Tier 1	Cattle	$GgCH_4$	50.89	50.36	52.95	55.97
Tier 2		$GgCH_4$	52.42	52.02	54.67	57.29
Difference		Percent	3.0	3.0	3.3	2.4
Tier 1	Livestock	$GgCH_4$	56.88	56.13	59.15	63.02
Tier 2		$GgCH_4$	58.41	57.79	60.87	64.34
Difference		Percent	2.7	2.7	3.0	2.9

6.3. MANURE MANAGEMENT

During the handling or storage of livestock manure, both CH_4 and N_2O are emitted. The magnitude of 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 more N_2O.

6.3.1.METHANE EMISSIONS FROM MANURE MANAGEMENT

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, in particular, the amount of aeration, and the quantity of manure.

Tier 1

Methane emissions from manure management are estimated using the IPCC Tier 1 approach, which relies on default emission factors. According to the IPCC 1996, the Tier 1 approach is likely to be sufficient for most animal types in most countries.

Activity Data: The animal population data is the same as those used for the Enteric Fermentation emission estimates (Tables 6.6-6.7).

Emission factors: Emission factors for late maturing cattle, buffalo, swine and poultry were taken according to default values for the Asia region IPCC 1996, Reference Manual, p. 4.13, Table 4.6, while for early maturing cattle, default values for the Eastern European region were used. For other types of animals, emission factors were taken according to default values for developing countries with a temperate climate [IPCC 1996, Reference Manual, p. 4.12, Table 4.5]. CH_4 emission factors for livestock categories are presented in Table 6.19.

Emissions: Calculated methane emissions from manure management are presented in Table 6.20

TABLE 6.19: METHANE EMISSION FACTORS AND EMISSIONS FROM MANURE MANAGEMENT (TIER 1)

Animal category	Population, thousand heads				Emission Factor, $kgCH_4$/head	Emission, $GgCH_4$			
	2010	2011	2012	2013		2010	2011	2012	2013
Late Maturing Cattle	877.5	868.2	913.0	965.0	1	0.88	0.87	0.91	0.97
Early Maturing Cattle	219.4	217.1	228.3	241.3	13	2.85	2.82	2.97	3.14
Buffalos	33.9	33.6	35.3	37.3	2	0.07	0.07	0.07	0.07
Sheep	721.2	694.1	753.8	873.7	0.16	0.12	0.11	0.12	0.14
Goats	70.7	64.7	60.6	67.0	0.17	0.01	0.01	0.01	0.01
Swine	168.3	127.4	190.7	288.2	4	0.67	0.51	0.76	1.15
Poultry	8,229.8	7,680.7	8,156.2	8,081.1	0.018	0.15	0.14	0.15	0.15
Total, Gg CH_4						**4.75**	**4.53**	**4.99**	**5.63**
Total GgCO2eq						**100**	**95**	**105**	**118**

TABLE 6.20: SHARE OF ANIMAL CATEGORIES IN METHANE EMISSIONS FROM MANURE MANAGEMENT FOR 2010-2013 YEARS

Animal category	2010	2011	2012	2013
Late Maturing Cattle	18.5	19.2	18.3	17.2
Early Maturing Cattle	60.1	62.3	59.5	55.8
Buffalos	1.4	1.5	1.4	1.3
Sheep	2.4	2.5	2.4	2.5
Goats	0.3	0.2	0.2	0.2
Swine	14.2	11.3	15.3	20.5
Poultry	3.1	3.1	2.9	2.6
Total, Gg CH_4	**100.0**	**100.0**	**100.0**	**100.0**

6.3.2. NITROUS OXIDE 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: Nitrous oxide emissions from manure management are estimated for each animal category by multiplying the animal population by the average nitrogen excretion rate associated with the specific animal category, and by the fraction of available nitrogen based on the type of waste management system.

The methodology is based on the following formulae:

$$N_2O_{(AWMS)} = \sum [Nex_{(AWMS)} \bullet EF_{3(AWMS)}],$$

$$Nex_{(AWMS)} = \sum_{(T)} [N_{(T)} \bullet Nex_{(T)} \bullet AWMS_{(T)}],$$

Where:

$N_2O_{(AWMS)}$	N_2O emissions from all AWMSs in the country (kg N/yr);
$EF_{3(AWMS)}$	N_2O emission factor for an AWMS (kg N_2O-N/kg of Nex in AWMS).
$Nex_{(AWMS)}$	N excretion per Animal Waste Management System (kg/yr);
$N_{(T)}$	Number of animals of type T in the country;
$Nex_{(T)}$	N excretion of animals of type T in the country (kgN/animal /yr);
$AWMS_{(T)}$	Fraction of Nex(T) that is managed in one of the different distinguished animal waste management systems for animals of type T in the country;
T	type of animal category;

Activity data: Animal population and distribution by categories for 2014-2030 were taken from Tables 6.7-6.8.

Emission factors: The average annual nitrogen excretion rates for domestic animals were taken according to default values for the Asia region from the IPCC 1996 [IPCC 1996, Reference Manual, p. 4.99, Table 4.20], presented in Table 6.21. The characteristics for this type of animals are most of all suitable to Georgian conditions.

TABLE 6.21: NITROGEN EXCRETION (NEX) FOR ANIMAL TYPES (KG/HEAD/YEAR)

Animal					
Early Maturing Cattle	Late Maturing Cattle	Poultry	Sheeps	Swine	Others
50	40	0,6	12	16	40

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 the Asia region were used [IPCC 1996, Reference Manual, p. 4.103, Table 4.21], as well as values based on the national agriculture expert judgment (Table 6.22).

TABLE 6.22: FRACTION OF MANURE NITROGEN IN DIFFERENT MANAGEMENT SYSTEMS

	Anaerobic Lagoons	Liquid Systems	Solid Storage and Drylot	Daily Spread	Pasture Range and Paddock	Other systems
Cattle			0.2	0.25	0.45	0.1
Poultry	0.01	0.02			0.44	0.53
Sheep					0.83	0.17
Swine	0.01		0.53	0.01		0.45
Others					0.95	0.05

Only an insignificant portion of manure nitrogen transforms into nitrous oxide. N_2O emission factors (kg N_2O-N/kg emitted nitrogen) for different manure management systems are given in Table 4.23. The 1996 IPCC default values were used [IPCC 1996, Reference Manual, p. 4.104, Table 4.22].

TABLE 6.23: DEFAULT VALUES OF N_2O EMISSION FACTORS FROM MANURE MANAGEMENT SYSTEMS (KG N_2O-N/KG EMITTED NITROGEN)

AWMS	Anaerobic Lagoons	Liquid Systems	Solid Storage and Drylot	Daily Spread	Pasture Range and Paddock	Other systems
Emission factor - EF3	0,001	0,001	0,02	0,0 (no range)	0,02	0,005

Emissions: N_2O Emissions from different manure management systems are given in Table 6.24, and their share in total emissions from manure management are given in Table 6.25.

TABLE 6.24: N_2O EMISSIONS (GG) FROM MANURE MANAGEMENT SYSTEMS IN 2010 - 2013

AWMS	AWMS Emission Factor, (kgN_2O–N/kgN)	Nitrogen Excretion GgN				Emissions GgN_2O			
		2010	2011	2012	2013	2010	2011	2012	2013
Anaerobic Lagoons	0.001	0.08	0.07	0.08	0.09	0.0001	0.0001	0.0001	0.0001
Liquid Systems	0.001	0.10	0.09	0.10	0.10	0.0002	0.0001	0.0002	0.0002
Solid Storage and Drylot	0.02	10.64	10.20	11.20	12.58	0.33	0.32	0.35	0.40
Other	0.005	10.12	9.53	10.49	11.70	0.08	0.07	0.08	0.09
Total						**0.41**	**0.40**	**0.43**	**0.49**
in CO_2eq						**128**	**123**	**135**	**151**

TABLE 6.25: SHARE OF MANURE MANAGEMENT SYSTEM IN *N_2O* EMISSIONS FROM MANURE MANAGEMENT

AWMS	2010	2011	2012	2013
Anaerobic Lagoons	0.02	0.03	0.02	0.02
Liquid Systems	0.05	0.03	0.05	0.04

Solid Storage and Drylot	80.5	80.0	81.4	81.6
Other	19.5	17.5	18.6	18.4
Total	**100.0**	**100.0**	**100.0**	**100.0**

6.4. AGRICULTURAL SOILS

Nitrous oxide emissions from agricultural soils consists 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.

6.4.1.DIRECT EMISSIONS FROM SOIL

N_2O direct emissions from soils (kg N/year) are calculated by following formula:

$$N_2O_{DIRECT} = N_2O_{SN} + N_2O_{AW} + N_2O_{CR} + N_2O_{(PR\&P)}$$

Where

N_2O_{SN} Nitrous oxide emissions from synthetic fertilizers

N_2O_{AW} Nitrous oxide emissions from the manure applied to soils

N_2O_{CR} Nitrous oxide emissions from agricultural residue decomposition.

$N_2O_{(PR\&P)}$ Nitrous oxide emissions from pasture ranges and paddocks.

6.4.1.1. SYNTHETIC NITROGEN FERTILIZERS

Synthetic fertilizers add large quantities of nitrogen to agricultural soils. This added nitrogen undergoes transformations, i.e. nitrification and denitrification, and releases N_2O. Emission rates associated with fertilizer application depends on many factors, such as the quantity and type of nitrogen fertilizers, crop types, soil types, climate and other environmental conditions.

Methodology: N_2O emissions were calculated by multiplying fertilizer consumption by the non-volatilized fraction (available for nitrification and denitrification) and by an emission factor:

$$N_2O_{SN} = F_{SN} \bullet EF_1$$

$$F_{SN} = N_{FERT} \bullet (1\text{-}FracGASF),$$

Where

F_{SN} synthetic nitrogen applied to soil (kgN);

EF_1 emission factor for direct soil emissions (kgN_2O-N/kgN input);

N_{FERT} synthetic fertilizer input (kgN);

$Frac_{GASF}$ fraction of total synthetic fertilizer nitrogen that is emitted as NO_x+NH_3(kgN/kgN);

Activity data: Data on the applied to soil synthetic N fertilizers were provided by the National Statistics Office of Georgia: Mainly ammonium nitrate (N content 34.5%) is used in Georgia. Data on applied to soil Synthetic N is presented in Table 6.27.

Emission factor: The IPCC default emission factor EF_1=0.0125 kgN_2O-N/kgN [IPCC 1996, Reference Manual, p. 4.89, Table 4.18] and default value of parameter $Frac_{GASF}$ =0.1 kg(NH_3-N+NO_x-N)/kgN [IPCC 1996, Reference Manual, p. 4.94, Table 4.19] were applied for all types of nitrogen fertilizers.

Emissions: N_2O emissions from synthetic fertilizers applied to soil in 2010-2013 are presented in Table 6.26.

TABLE 6.26: N_2O DIRECT EMISSIONS FROM FERTILIZERS

Year	Synthetic Fertilizer N Applied to Soil, GgN	Amount of N Input, GgN	N_2O Emissions	
			GgN_2O	GgCO_2eq
2010	17.319	15.587	0.31	95
2011	14.939	13.445	0.26	82
2012	17.078	15.370	0.30	94
2013	22.287	20.058	0.39	122

6.4.1.2. ANIMAL MANURE APPLIED TO SOILS

As a rule, all the manure from manure management systems is applied to agricultural soils. The application of animal manure as fertilizer to soils can increase the rate of nitrification /denitrification, and result in enhanced N_2O emissions from agricultural soils. Emissions from this category include manure managed by dry lot, liquid and other AWMS. Manure deposited on grazing land were included in manure on Pasture and Paddock.

Methodology: Emissions were calculated by multiplying the amount of manure nitrogen applied to agricultural soils by the non-volatilized fraction by an emission factor:

$$N_2O_{AW} = F_{AW} \bullet EF_1$$

$$F_{AW} = [Nex \bullet (1-(FracFUEL + FracGRAZ + FracGASM)];$$

Where

F_{AW} manure nitrogen used as fertilizer in country, corrected for NH_3 and NO_x emissions and excluding manure produced during grazing (kg N);

EF_1 emission factor for direct soil emissions (kg N_2O-N/kg N input);

$Frac_{FUEL}$ fraction of livestock nitrogen excretion contained in excrements burned for fuel (kg N/kg N totally excreted);

$Frac_{GRAZ}$ fraction of livestock nitrogen excreted and deposited onto soil during grazing (kgN/kgN excreted) country estimate;

$Frac_{GASM}$ fraction of livestock nitrogen excretion that volatilizes as NH_3 and NO_x (kg NH_3-N and NO_x-N/kgN excreted).

Activity data: The animal population data is the same as those used for the Enteric Fermentation estimates (Tables 6.7-6.8).

Emission factor: The IPCC 1996 default emission factor EF_1=0.0125 kgN_2O-N/kgN and default value of parameter $Frac_{GASM}$ =0.2 kg(NH_3-N + NO_x-N)/kgN were used [IPCC 1996, Reference Manual, p. 4.94, Table 4.19]. In Georgia, only a small amount of manure is burned, $Frac_{FUEL}$=0. Values of FracGRAZ are given in Table 6.27.

Calculated Emissions: Estimated nitrous oxide emissions from manure applied to soil are presented in Table 6.27.

TABLE 6.27: ESTIMATED NITROUS OXIDE EMISSIONS FROM MANURE APPLIED TO SOIL IN YEARS 2010-2013.

Year	Total Manure Nitrogen Excretion, GgN	Fraction on Manure Nitrogen			Manure Nitrogen Applied to Soils, GgN	N_2O Emissions	
		Excreted During Grazing	Emitted as NO_x and NH_3	Applied to Soil		GgN_2O	GgCO_2eq
2010	66.535	0.51	0.2	0.29	19.168	0.38	117
2011	64.491	0.51	0.2	0.28	18.404	0.36	112
2012	68.761	0.51	0.2	0.29	20.133	0.40	123
2013	74.781	0.51	0.2	0.29	22.227	0.44	135

6.4.1.3. DECOMPOSITION OF CROP RESIDUES

After harvesting, part of the agricultural crop residues is left in the field and decompose. They represent a nitrogen source. As a result of the transformation nitrous oxide is formed.

Methodology: emissions are calculated by multiplying the amount of nitrogen in crop residues (both: nitrogen fixing and non-fixing crops) by the nitrous oxide emission factor:

$$N_2O_{CR} = F_{CR} \bullet EF_1$$

$$F_{CR} = 2 \bullet (Crop0 \bullet FracNCR0 + CropBF \bullet FracNCRBF) \bullet (1\text{-}FracR) \bullet (I\text{-}FracBURN);$$

Where

F_{CR} N in crop residues returned to soils, kg N

EF_1 emission factor for direct soil emissions (kg N2O-N/kg N input)

Crop0 production non-N fixing crops in country (kg dry biomass);

FracNCR0 fraction of nitrogen in non-N-fixing crop (kg N/kg of dry biomass)

CropBF seed yield of nitrogen-fixing crops (kg dry biomass/yr);

FracNCRBF fraction of nitrogen in N-fixing crop (kg N/kg of dry biomass)

FracR fraction of crop residue that is removed from the field as crop (kg N/kg crop-N);

FracBURN fraction of crop residue that is burned rather than left on field.

Activity data: Data on agriculture crop production were provided by the National Statistics Office of Georgia.

Emission factors: Default values for the fraction of nitrogen, from the 1996 IPCC, were used: for N fixing crop residues FracNCRBF =0.03 kgN/kg dry mass and for non N fixing crop residues FracNCR0=0.015 kgN/kg dry mass [IPCC 1996, Reference Manual, p. 4.94, Table 4.19]. For the emission factor, the 1996 IPCC default value was used EF_1=0.0125 kg(N_2O-N)/kgN. FracR=0.45, FracBURN=0.25 [IPCC 1996, Reference Manual, p. 4.94, Table 4.19].

Emissions: N_2O emissions from crop residue decomposition are given in Table 6.28.

TABLE 6.28: N_2O EMISSIONS FROM CROP RESIDUE DECOMPOSITION

Year	Nitrogen input from Crop Residues, kgN	Emissions	
		GgN2O	$GgCO_2eq$
2010	3.293	0.06	20
2011	5.515	0.11	34
2012	5.375	0.11	33
2013	6.450	0.13	39

6.4.2.EMISSIONS FROM PASTURE RANGES AND PADDOCKS

Emissions from manure dropped on the soil during grazing on grasslands (pasture range and paddock) were 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: emissions from manure excreted by grazing animals were 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.

The Methodology was based on the following formula:

$$N_2O_{(PR\&P)} = \{\sum_{(T)} [N_{(T)} \bullet Nex_{(T)} \bullet PR\&P_{(T)}]\} \bullet EF_{(PR\&P)},$$

Where:

$N_2O_{(PR\&P)}$ N_2O emissions from pasture range and paddock (kg N/yr);

$EF_{(PR\&P)}$ N_2O emission factor for pasture range and paddock (kg N_2O-N/kg of Nex in PR&P).

$N_{(T)}$ number of animals of type T in the country;

$Nex_{(T)}$ N excretion of animals of type T in the country (kgN/animal /yr);

$PR\&P_{(T)}$ fraction of Nex(T) that is managed in pasture range and paddock for animals of type T in the country;

T type of animal category.

Activity data: The animal population data is the same as those used in the Enteric Fermentation emission estimates (Table 6.7).

Emission factors: The average annual nitrogen excretion rates for domestic animals were taken according to default values for the Asia region (see Table 6.22). The fraction of manure nitrogen available for conversion to N_2O was calculated as the percentage of total manure nitrogen produced on pasture and paddock (see Table 6.21) multiplied by the IPCC default value of 0.02 kg N_2O-N/kg N [IPCC 1996, Reference Manual, p.4.97] and [IPCC 1996, Reference Manual, p. 4.104, Table 4.22], which represents the fraction of excreted manure nitrogen converted to N_2O. $PR\&P_{(T)}$ values are presented in Table 6.22.

Emissions: N_2O emissions from pastures and paddocks are given in Table 6.29.

TABLE 6.29: N_2O EMISSIONS FROM PASTURES AND PADDOCKS

Year	Nitrogen Excretion kgN	Emissions	
		GgN_2O	$GgCO_2eq$
2010	34,060,139	1.07	332
2011	33,188,511	1.04	323
2012	34,875,855	1.10	341
2013	37,597,932	1.18	366

TABLE 6.30: DIRECT N_2O EMISSIONS FROM SOILS IN 2010 – 2013

Source	2010	2011	2012	2013
N Fertilizers	0.31	0.26	0.30	0.39
Manure Applied to Soils	0.38	0.36	0.40	0.44
Crop Residue Decomposition	0.06	0.11	0.11	0.13
Pasture Range and Paddock	1.07	1.04	1.10	1.18
Total N2O	**1.82**	**1.77**	**1.91**	**2.14**
CO2eq in Gg	**564**	**549**	**592**	**663**

6.4.3. INDIRECT NITROUS OXIDE EMISSIONS FROM SOILS

A fraction of the fertilizer nitrogen (from both synthetic fertilizer and manure) that is applied to agricultural fields is transported off-site, either through volatilization and subsequent re-deposition or leaching, erosion and runoff. The nitrogen, which is transported from the agricultural field in this manner, provides 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.

6.4.3.1. VOLATILISATION AND RE-DEPOSITION OF NITORGEN

When synthetic fertilizer or manure is applied on cropland, a portion of this nitrogen is lost through volatilization in the form of NH_3 or NO_x. This volatilized nitrogen can be re-deposited somewhere else, and can undergo further transformations, such as nitrification and denitrification, thus, resulting in N_2O emissions offsite. The quantity of this volatilized nitrogen depends on a number of factors, such as rates, fertilizer types, methods and time of nitrogen application, soil texture, rainfall, temperature, soil pH, etc.

$$N_2O(G) = (N_{FERT} \bullet FracGASF + N_{EX} \bullet FracGASM) \bullet EF_4$$

Where:

N_{FERT}	synthetic fertilizer use in country (kgN/yr);
$Nex_{(T)}$	N excretion of animals of type T in the country (kgN/animal /yr);
FracGASF	fraction of synthetic fertilizer nitrogen applied to soils that volatilizes as NH3 and NOx (kg NH3-N and NOx–N/kg of N input)
FracGASM	fraction of livestock nitrogen excretion that volatilizes as NH3 and NOx (kgNH_3-N and NOx-N/kg of N excreted).
EF_4	emission factor for atmospheric deposition (kg N_2O-N/kg N input);

Methodology: The 1996 IPCC methodology is used to estimate indirect N_2O emissions due to volatilization and re-deposition of nitrogen from applied synthetic fertilizer and manure. The amount of synthetic fertilizer consumption is multiplied by the fraction of nitrogen that is volatilised as NH_3 and NO_x and then by an emission factor.

Activity data: The amount of N fertilizers is sourced from the Ntional Statistics Office of Georgia.

Emission factor: The IPCC default emission factor is applied to derive the N_2O emission estimate EF_4 =0.01 kg(N_2O-N)/kgN [IPCC 1996, Reference Manual, p. 4.105, Table 4.23]. The amount of nitrogen that volatilizes is assumed to be 10% of synthetic fertilizer applied and 20% of manure nitrogen applied, i.e. FracGASF=0.1 and FracGASM=0.2 [IPCC 1996, Reference Manual, p. 4.94, Table 4.19].

Emissions: Estimated GHG emissions are presented in Table 6.31

TABLE 6.31: ESTIMATED N_2O EMISSIONS FROM VOLATILISATION AND RE-DEPOSITION IN 2010 - 2013

Year	Synthetic Fertilizer N Applied to Soil, kgN	Amount of Synthetic N Applied to Soil that Volatilizies,kgN	Total Excretion by Livestock, kgN	Total Excretion by Livestock that Volatilizes, kgN	Total N that Volatilizes kgN	Emissions	
						GgN_2O	$GgCO_2eq$
2010	17,319,000	1,731,900	66,534,680	13,306,936	15,038,836	0.24	73
2011	14,938,500	1,493,850	64,490,620	12,898,124	14,391,974	0.23	70
2012	17,077,500	1,707,750	68,761,120	13,752,224	15,459,974	0.24	75
2013	22,287,000	2,228,700	74,780,860	14,956,172	17,184,872	0.27	83

6.4.3.2. LEACHING, EROSION AND RUNOFF

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.

Emissions where calculated by following formula:

$$N_2O(L) = N_{LEACH} \bullet EF_5$$

$$N_{LEACH} = [N_{FERT} + Nex] \bullet FracLEACH$$

Where:

N_{LEACH}	Leached nitrogen N (kgN/year);
Nex	N excretion of animals of type (kgN/animal);
N_{FERT}	synthetic fertilizer use in country (kgN);
FracLEACH	fraction of fertilizer and manure nitrogen excretion that leaches
EF_5	emission factor for leaching and runoff (kgN_2O-N/kgN leaching/runoff);

Methodology: The IPCC methodology estimates N_2O emissions from runoff and leaching of nitrogen by assuming that 30% of the nitrogen applied as synthetic fertilizer or manure is lost by leaching or runoff FracLEACH=0.3 [IPCC 1996, Reference Manual, p. 4.106, Table 4.24] and multiplies this by the leaching factor to obtain an emission estimate.

Activity data: data on nitrogen applied is given in Table 6.33.

Emission factor: The IPCC default leaching emission factor of 0.025 kg N_2O-N/kg N leaching/runoff was used [IPCC 1996, Reference Manual, p. 4.105, Table 4.23].

Emissions: N_2O emissions from Leaching, Erosion and Runoff of Nitrogen for 2010-2013 years are given in Table 6.32.

TABLE 6.32: N_2O EMISSIONS FROM LEACHING AND RUNOFF IN 2010-2013

Year	Synthetic Fertilizer Use, GgN	Livestock Excretion, GgN	Emissions	
			GgN_2O	$GgCO_2eq$
2010	17.319	66.535	0.99	306
2011	14.939	64.490	0.94	290
2012	17.078	68.761	1.01	314
2013	22.287	74.781	1.14	355

6.5. FIELD BURNING OF AGRICULTURE RESIDUES

Burning of crop residues is not thought to be a net source of carbon dioxide, asthe carbon released to the atmosphere during burning is reabsorbed during the next growing season. Calculations were carried out applying the 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 2010-2013, the share of methane emissions from this source in the sectoral emissions were within 0.15–0.27%, and the share of Nitrous oxide emissions within 0.07–0.12%. Carbon monoxide and nitrogen oxides are also emitted during field burning of crop residues.

Emissions: Methane and nitrous oxide emissions, as well as carbon monoxide and nitrogen oxides emissions in 2010-2013 are presented in Table 6.33.

TABLE 6.33: EMISSIONS FROM FIELD BURNING OF CROP RESIDUES

Year	Emissions						Total $GgCO_2eq$
	GgCO	*$GgNO_x$*	$GgCH_4$	$GgCO_2eq$	GgN_2O	$GgCO_2eq$	
2010	*3.55*	*0.18*	0.169	4	0.005	2	6
2011	*6.06*	*0.31*	0.288	6	0.009	3	9
2012	*5.59*	*0.29*	0.266	6	0.008	2	8
2013	*7.32*	*0.37*	0.348	7	0.010	3	10

7. LAND USE LAND, USE CHANGE AND FORESTRY (LULUCF)

7.1. GENERAL OVERVIEW OF THE SECTOR

In 2014, in the framework of the third national greenhouse gas inventory report, the LULUCF sector inventory report was prepared covering 1992 to 2011. In particular, recalculations were made for the emissions/removals estimation for 1992 to 2007, while new GHG emissions/removals estimations were provided for 2008-2011. The first biennial update report for 2010-2013 was conducted in the framework of the institutional and technical ability improvement of the national GHG inventory in Georgia. For 2010-2011, updated data was used, and new estimations were provided for the GHG inventory for 2012-2013.

In general, according to the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG LULUCF), the greenhouse gas inventory in LULUCF should be conducted based on the proposed top-level land categories classification: 1) Forest land (5A); 2) Cropland (5B); 3) Grassland (5C); 4) Wetlands (5D); 5) Settlements (5E); 6) Other land (5F). Pursuant to IPCC requirements, the availability of annual comprehensive land cadaster, and envisaging the changes developed in this cadastre in the land use field, is significant and essential for the inventory of this source category.

Based on the data provided by FAOSTAT, the National Statistics Office of Georgia and the Ministry of Environment and Natural Resources Protection of Georgia, the Table 7.1 presents the area distribution of the country following the IPCC land-use classification from 2010, including 2013.

Almost in every land use category, there was no change in the area according to the most updated data, concerning 2010-2013. Forest land area remained stable and this is the result of the absence of clear cuts in Georgia, which could lead to the land-use conversion from forest land to other land use categories, and of the conversion to forest land.

Greenhouse gas emissions/removals in the forest land category were estimated only for forested areas where economic activity is allowed. Carbon stock changes were not assessed in areas where none of such activities officially took place, as well as in areas that are not under the control of the official government. These activities are necessary in order to distinguish how high or low the biomass decrease rate is in comparison with forest regeneration and increment volume, and if the forest represents a sink or source of GHG.

TABLE 7.1 DISTRIBUTION OF THE TERRITORY OF GEORGIA BY LAND USE CATEGORIES

(Data of FAOSTAT, the National Statistics Office of Georgia[37] and the Ministry of Environment and Natural Resources Protection[38]), Thousand ha

Land Categories	Land Use Subcategories	Year			
		2010	2011	2012	2013
Forest Land	Forests where economic activities take place.	2521.8	2521.8	2521.8	2521.8
	Protected forested areas	300.6	300.6	300.6	300.6

[37] http://www.fao.org/statistics/en/

[38] http://moe.gov.ge/index.php?lang_id=GEO&sec_id=43

Land Categories	Land Use Subcategories	Year			
		2010	2011	2012	2013
	Total	2822.4	2822.4	2822.4	2822.4
Cropland	Annual croplands	125	125	125	125
	Perennial cropland	415	402	400	451
	Total	540	527	525	576
Grassland	Pasture	1804.2	1804.2	1804.2	1804.2
	Hayland	135.8	135.8	135.8	135.8
	Total	1940	1940	1940	1940
Wetlands	Territorial waters (Black Sea) area	679	679	679	679
	Wetlands	215.1	215.1	215.1	215.1
	Total	894.1	894.1	894.1	894.1
Settlements		88.4	88.4	88.4	88.4
1. *Other land (including the area of Forest Fund[39])*		1343.5	1343.5	1356.5	1307.5
Total area of Georgia		**7628.4**	7628.4	7628.4	7628.4
Country's land area		**6949.4**	6949.4	6949.4	6949.4

In the Table above, the other land category covers unused lands such as rocks, canyons, sandy grounds, eroded and landslide affected lands, glaciers, areas occupied by cemeteries, as well as the areas of the Forest Fund. Table 7.1 shows that forest land represents the prime proportion (40 %) of the country's land area. The importance of this category is increased in the greenhouse gas inventory, taking into consideration that forest land is much more actively interacting with the atmosphere compared to other land use categories, due to the abundance of deciduous and coniferous cover, and has a leading role in absorbing carbon dioxide and carbon accumulation.

7.2. TOTAL EMISSIONS FROM THE LAND USE, LAND-USE CHANGE AND FORESTRY SECTOR (2010-2013)

In this sector, calculations were carried out using default values of emission factors (Tier I approach), which approximately comply with Georgia's climate conditions. Table 7.2 demonstrates the carbon dioxide emissions per each land use category, as well as total emissions calculated for the whole inventory period 2010-2013. Estimation methodologies, activity data and emission factors are explained in detail in the respective chapters below. In Table 7.2, the (+) symbol corresponds to CO2 emissions to and the (-) to CO2 accumulation from the atmosphere.

Grasslands (5C) act as carbon emitter in each evaluated year, which is caused by the degradation of pasture lands, especially in eastern Georgia. This land use category becomes a

[39] Forest Fund area that is included in the other land category comprises areas which are not forested and have not been included in any of the other land use categories.

carbon emitter due to intensive irregular exploitation of pastures. Hence, the scale of carbon taken up by soils is scarce.

The greenhouse gas inventory was conducted by applying the gain-loss method in forest land category, as proposed by the IPCC methodology. Electronic tables were filled out. The calculations showed that the forest land cateogry in Georgia accumulates carbon in each assessed year. It should be mentioned, that the official logging volume conducted for different purposes (which was used in calculations) is less than it is in reality. This conclusion is based on the information obtained from various sources in Georgia, for example, from a study conducted by the Austrian Development Agency (ADA) in the forest area of the Borjomi-Bakuriani municipality in 2014. Based on the data of Borjomi-Bakuriani forest area inventory conducted in 2014, carbon stocks were assessed through two methods: the gain-loss method and the stock change method comparing carbon stocks, a comparative analysis was carried out.

Studies have shown that the results produced by the gain-loss method indicate that forests accumulate carbon steadily, while at the same time the results produced by the comparison between carbon stocks show that forest area is an emitter as well. The difference was mainly caused by irrelevant difference between officially reflected forest cuts during many years, while the forest inventory revealed losses of timber resources. As for the method of calculating, the difference between stocks for the entire country is complicated by the fact that renewed data on the country's total forest resources do not exist. The inventory, particularly during last decades, has not been carried out, except for some limited number of forest areas.

In total, as the calculations show, the dynamics of carbon accumulation is almost equal from year to year, and fluctuates between 1148- 1056 thousand tons of carbon.

Emissions and removals from the land use, land use change and forestry sector in 2010-2013 are given in Table 7.2.

TABLE 7.2 CARBON STOCK CHANGES (CSCS) AND CO_2 EMISSIONS/REMOVALS IN LAND USE, LAND-USE CHANGE AND FORESTRY SECTOR IN 2010-2013

Year	Forest Land		Cropland: Annual Croplands		Cropland: Perennial Woody Crops		Grassland (Hayfields and Pastures)		Net Emission/Removals	
	Carbon stock net change Thousand tC	Gg CO_2	Carbon stock net change Thousand tC	Gg CO_2	Carbon stock net change Thousand tC	Gg CO_2	Carbon stock net change Thousand tC	Gg CO_2	Carbon stock net change Thousand tC	Gg CO_2
2010	1,420	(5,207)	46	(170)	263	(963)	(674)	2,470	1 055	-3,869
2011	1,527	(5,597)	32	(118)	263	(963)	(674)	2,470	1148	-4,208
2012	1,491	(5,467)	31	(114)	263	(963)	(674)	2,470	1 111	-4,073
2013	1,501	(5,502)	35	(129)	263	(963)	(674)	2,470	1 125	-4,124

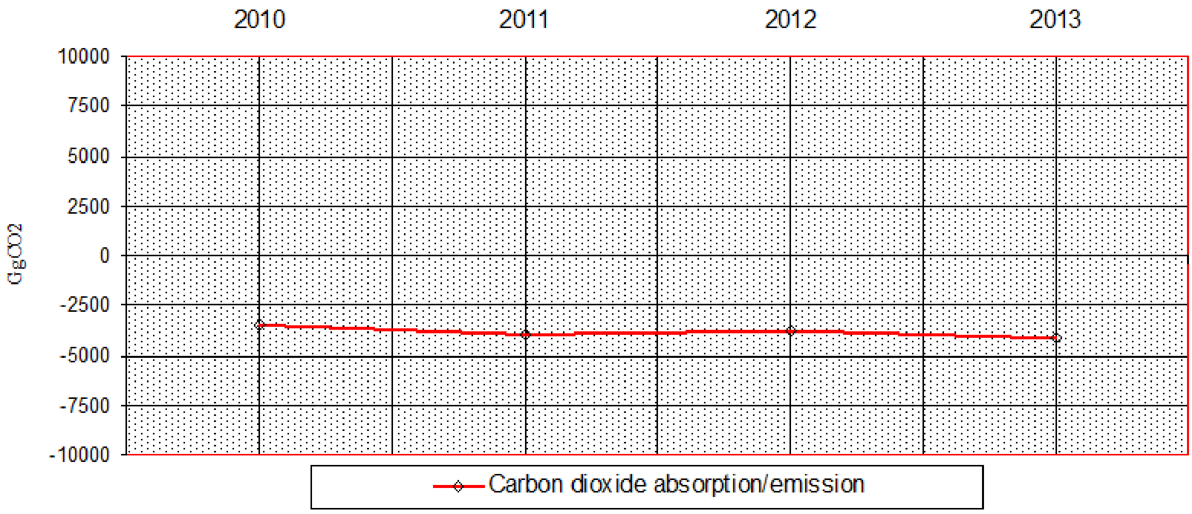


FIG.7.1 TOTAL GHG NET EMISSIONS/REMOVALS FROM LULUCF SECTOR CALCULATED FOR 2010-2013

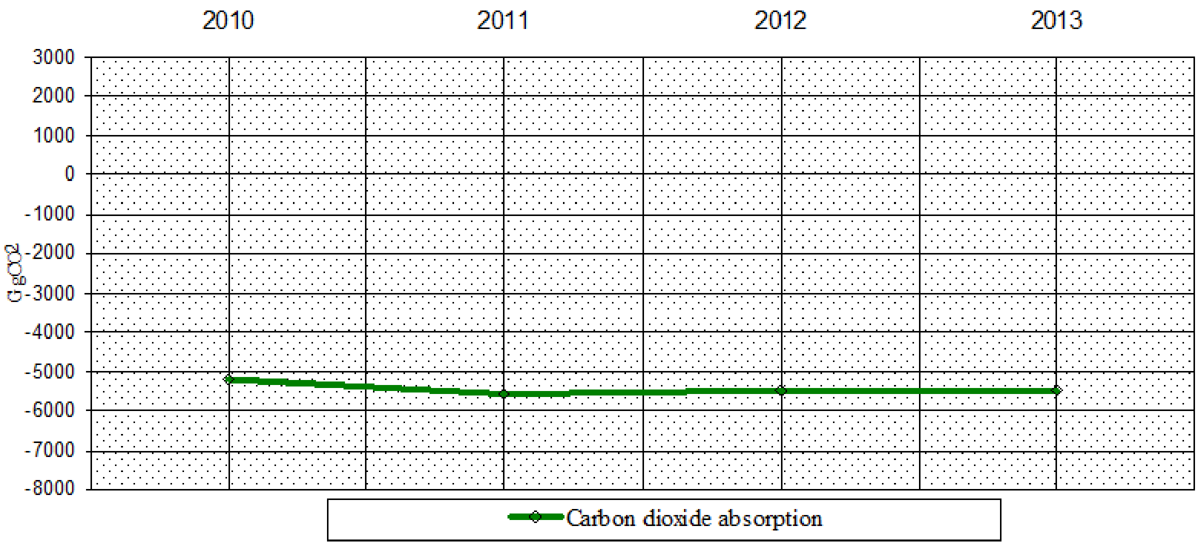


FIG. 7.2 DYNAMICS OF CARBON DIOXIDE NET EMISSIONS/REMOVALS IN FOREST LAND CATEGORY CALCULATED FOR 2010-2013

7.3. FOREST LAND

7.3.1. DESCRIPTION OF SOURCE CATEGORY

Absorption of carbon dioxide (CO_2) from the atmosphere is a permanent process in forests and its reverse flow is, partially, the result of natural processes and anthropogenic activities. The component of absorbed carbon dioxide - Carbon (C) is accumulated in forest biomass, while released oxygen (O_2) is returned to the atmosphere. These processes vary in different types of forests and forests of different age. Consequently, it is common to consider them separately for deciduous and coniferous forests, taking into consideration the age parameter.

Within the context of the present report, the inventory of Georgian forest land was undertaken only on the forest land areas where economic activities take place, and which impact the annual

change of carbon stocks. The calculations were made in compliance with the IPCC Guidelines[40], and its schematic structure is presented in Fig.7.3.

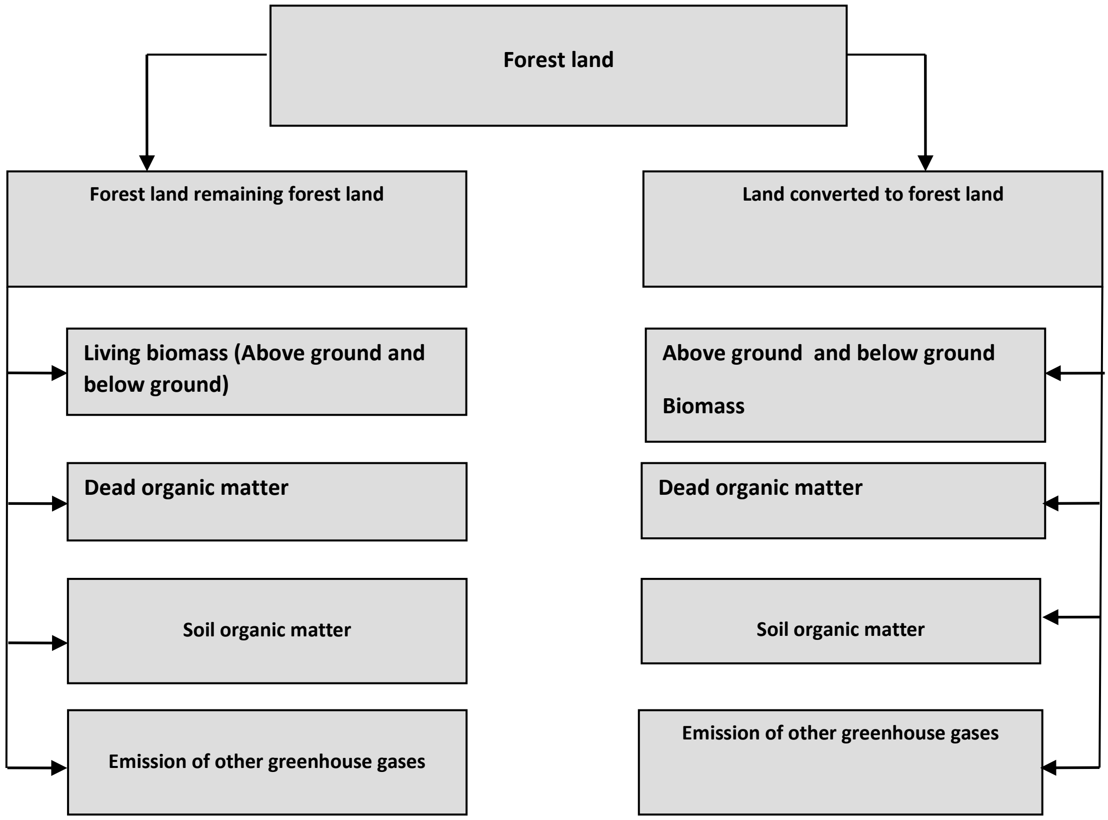


FIG.7.3. THE ESTIMATING STRUCTURE OF FOREST LAND CATEGORY

As demonstrated by this scheme, calculations in the forest land category are divided in two parts: forest land remaining forest land (meaning the forest area has not changed during the inventory, i.e. remained in the same state), and the land area that converted during the inventory period, meaning lands of different categories transformed into forest land, i.e. they were afforested or reforested (naturally or artificially as a result of anthropogenic activity) and included into forest land.

According to the IPCC methodology, lands of different categories, transformed into forest land, remain in this transition status for 20 years. Subsequently, they were included in the Forest land remaining forest land category. However, according to the methodology, recovery might need more time.

7.3.2. METHODOLOGY

a) Used method

The methodology of greenhouse gas inventory is based on good practice principles, which means calculations by levels (tiers). In particular, there are 3 tiers/levels:

[40] Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 3, Forest land, IPCC 2003, http://www.ipcc-nggip.iges.or.jp

Tier 1- calculation levels given in IPCC Guidelines[41] were used. The same document provides factors, necessary for the calculation of emissions/removals, which are already determined for the countries grouped by climate zones;

Tier 2- approach provided for the 1st level were used in the calculations, but in this case in addition country-specific factors, were used;

Tier 3 – more complicated methods were used, in which the results of modeling and measurements, adapted for the country conducting the cadaster, are included.

The selection of the acceptable level for calculation, depends on the availability of the necessary data. Also, to improve conducting the cadaster, when choosing the appropriate level, attention should be paid to the source category of emissions (land use category), where the carbon stock changes are larger than in others, considering it a key source category.

According to the IPCC methodology, in the forest land category carbon is accumulated in carbon pools:

1) living biomass (above ground and below ground);
2) dead organic matter (dead wood, litter);
3) soil organic matter (mineral and organic soils).

Explanation of these pools is provided in Table 7.3.

The Forest land remaining forest land category was selected as key element for the calculations, based on materials required for cadastre in Georgia, collected in advance, and the appropriate guidelines. In Georgia, conversion of forest land into other categories or vice versa is quite rare. From carbon pools, living biomass was selected, mainly in which changes in carbon stocks take place.

TABLE7.3. 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 fallen down on the soil, not decayed
		Litter	All dead cover (humus) in about 10 centimeters depth
3	Soils	Organic Matter of Soil	Organic carbon in determined depth of mineral and organic soils (including peats).

Calculations were conducted separately in two regions of Georgia, for coniferous and deciduous forests in West and East Georgia forest land areas.

Fig. 7.4 demonstrates the equation used to calculate carbon deposits[42]. The calculations were conducted only for above ground and below ground biomass, and the living biomass pool.

[41]Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 3,Tier Levels, IPCC 2003,http://www.ipcc-nggip.iges.or.jp

[42]Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 3,Forest Land Remaining Forest Land, IPCC 2003,http://www.ipcc-nggip.iges.or.jp

$$\Delta C_{FF} = (\Delta C_{FF_{LB}} + \Delta C_{FF_{DOM}} + \Delta C_{FF_{SOILS}})$$

$$\Delta C_{FF_{LB}} = (\Delta C_{FF_G} - \Delta C_{FF_L})$$

$$C_{FF_G} = (A \cdot G_{TOTAL}) \cdot CF$$

$$G_{TOTAL} = G_W \cdot (1 + R)$$

$$G_W = I_V \cdot D \cdot BEF_1$$

$$\Delta C_{FF_L} = L_{fellings} + L_{fuelwood} + L_{other\ losses}$$

$$L_{fellings} = H \cdot D \cdot BEF_2 \cdot (1 - F_{BL}) \cdot CF$$

$$L_{fuelwood} = FG \cdot D \cdot BEF_2 \cdot CF$$

$$L_{other\ losses} = A_{DISTURBANCE} \cdot B_W \cdot (1 - F_{BL}) \cdot CF$$

FIG.7.4 THE SYSTEM OF EQUATIONS FOR CALCULATION OF THE AMOUNT OF CARBON ACCUMULATION IN BIOMASS

Where

ΔCFF annual change in carbon stocks from forest land remaining forest land, tonnes C yr-1;

$\Delta C_{FF_{LB}}$ annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land remaining forest land; tonnes C yr-1;

$\Delta C_{FF_{DOM}}$ annual change in carbon stocks in dead organic matter (includes dead wood and litter) in forest land remaining forest land; tonnes C yr-1;

$\Delta C_{FF_{SOILS}}$ annual change in carbon stocks in soils in forest land remaining forest land; tonnes C yr-1;

ΔC_{FF_G}annual increase in carbon stocks due to biomass growth, tonnes C yr-1;

ΔC_{FF_L}- annual decrease in carbon stocks due to biomass loss, tonnes C yr-1;

A - Area of forest land 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), tonnes C (tonne 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;

$L_{felling}$ – annual carbon loss due to commercial felling, tonnes C yr-1

$L_{fuelwood}$- annual carbon loss due to fuel wood gathering, tonnes C yr-1

$L_{other\ losses}$ –annual other losses of carbon, tonnes C yr-1

H-annually extracted volume, round wood, m3 yr-1;

BEF_2-biomass expansion factor for converting volumes of extracted round wood 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 fuel wood gathering, m3 yr-1;

B_W-average biomass stock of forest areas, tonnes d.m. ha-1;

In addition, natural processes occuring in forest land and changes in carbon stocks as a result of wood production, were also calculated.

As a result of forest fires CH_4, N_2O, CO, and NO gases are emitted together with CO_2 emissions.

Existing methodology offers an opportunity to define the volume of carbon released as a result of forest fire, as well as of other greenhouse gases (CH_4, N_2O); the calculations were made using the following equation[43]:

$$L_{FIRE}=A\bullet B\bullet C\bullet D\bullet 10^{-6}$$

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 abovementioned equation is used to calculate the volumes of all greenhouse gases separately, since the emission factor is different for different gases (Table 7.10).

[43]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

b) Activity Data

In Table 7.4 commercial covered areas of forestlands in Georgia for 2010-2013 are given. Since the East and West Georgian forests, as well as the climatic conditions, are significantly different from each other, the forested area (2 822.4 thousand ha) was divided into the eastern dry and western humid climate of forests and forest types (coniferous and deciduous) to increase the calculation accuracy. In addition, separate calculations were made for forest areas in Adjara.

Data on annual average expansion of forest lands, for both types of forests in different climate zones, were taken separately, based on, respective, various taxation or statistical data[44].

TABLE 7.4. FOREST LAND AREAS

Year	West Georgia			East Georgia			Autonomous Republic of Adjara			Abkhazia and South Ossetia	Agency of Protected Areas, Forest. Land	Georgia, the total forest area, ha
	Coniferous, ha	Deciduous, ha	Total	Coniferous, ha	Deciduous, ha	Total	Coniferous, ha	Deciduous, ha	Total			
1	2	3	4	5	6	7	8	9	10	11	12	13
2010	152979	729 995	**882 974**	139 060	778 827	**917 887**	45 237	114 592	**159 829**	**561 139**	**300 571**	**2 822 400**
2011	152979	729 995	**882 974**	139 060	778 827	**917 887**	45 237	114 592	**159 829**	**561 139**	**300 571**	**2 822 400**
2012	152979	729 995	**882 974**	139 060	778 827	**917 887**	45 237	114 592	**159 829**	**561 139**	**300 571**	**2 822 400**
2013	152979	729 995	**882 974**	139 060	778 827	**917 887**	45 237	114 592	**159 829**	**561 139**	**300 571**	**2 822 400**

TABLE 7.5 MEAN ANNUAL INCREMENT OF FOREST AREAS IN M^3/HA

	West Georgia	East Georgia	Autonomous Republic of Adjara
Coniferous	2.5	3.1	3.8
Deciduous	1.7	2.2	2.9

[44] Statistical publication of Forestry Department of Georgia, WWF – Caucasus Office, Tbilisi, 2006; G. Mirzashvili, G. Kuparadze; Forestry taxation handbook, Tbilisi 1960; Forest inventory data of 2005, Adjara

As mentioned above, the steady annual state of forest land area is conditioned by the fact that clearcutting is hardly practiced in Georgia and, consequently, after various cuttings allowed in the country (basically maintaining cuttings) those lands have not completely lost their forest cover.
Table 7.6 and Table 7.7 provide information on volume of timber and firewood produced in 2010-2013 in Georgia.

TABLE 7.6. TIMBER PRODUCED IN GEORGIA IN 2010-2013

Year	West Georgia m³	East Georgia m³	Autonomous Republic of Adjara m³	Agency of Protected Areas, Forest. Land	Abkhazia and South Ossetia	Total
1	2	3	4	5	6	7
2010	49 878	35 280	1 390	-	-	86 548
2011	32 145	29 256	9 021	-	-	70 422
2012	45 404	21 874	11 361	-	-	78 639
2013	44 639	30781	5 705	-	-	81 125

TABLE 7.7. FIREWOOD PRODUCED IN GEORGIA IN 2010-2013

Year	West Georgia m³	East Georgia m³	Autonomous Republic of Adjara m³	Agency of Protected Areas, Forest. Land m³	Abkhazia and South Ossetia	Total
1	2	3	4	5	6	7
2010	110 544	556 737	78 478	29 632	-	775 391
2011	100 214	341 820	88 538	33 601	-	564 173
2012	98 428	399 917	60 809	34 564	-	593 718
2013	102 529	447 848	70 635	1 690	-	621 012

c) Emission Factors

Basic wood density (D) was calculated for forests of East and West climate regions, and for deciduous and coniferous separately.

The data on reserves of species dominating in the forests of both regions were used to calculate the results. The values of specific weight of harvested timber are provided in Tables 7.8; 7.9 and 7.10

TABLE 7.8. BASIC WOOD DENSITY OF DECIDUOUS AND CONIFEROUS FORESTS IN WEST GEORGIA

(Volumes of reserves are calculated by averaging 2006-2011 data)

Dominant forest species	Reserves of dominating species (m^3) and share in total reserves (%)	Basic wood density timber, t/m^3[45]
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 7.9. BASIC WOOD DENSITY OF DECIDUOUS AND CONIFEROUS FORESTS IN EAST GEORGIA

(Volumes of reserves are calculated by averaging 2006-2011 data)

Dominant forest species	Reserves of dominating species (m^3) and share in total reserves (%)	Basic wood density timber, t/m^3[46]
Deciduous		
Beech	65 569(45)	0.58
Chestnut	61 085(31)	0.66
Alder	39 250(12)	0.74
Oak	9 369(8)	0.74
Hornbeam	4 025(4)	0.65
Total	179 298(100)	
Basic wood density		**0.65**
Coniferous		
Pine	21 365(61)	0.48
Fir	10025(28)	0.41
Spruce	3 258(9)	0.44
Total	34 648(100)	
Basic wood density		**0.45**

[45] Makhviladze. Timbers, Tbilisi 1962; Боровиков А.М., Уголев Б.Н.. Справочникподревесине. “ЛеснаяПромышленность”, Москва, 1989;

[46] Makhviladze. Timbers, Tbilisi 1962; Боровиков А.М., Уголев Б.Н.. Справочникподревесине. “ЛеснаяПромышленность”, Москва, 1989;

TABLE 7.10. BASIC WOOD DENSITY OF DECIDUOUS AND CONIFEROUS FORESTS IN AUTONOMOUS REPUBLIC OF ADJARA

(Volumes of reserves are calculated by averaging 2006-2011 data)

Dominant forest species	Reserves of dominating species (m^3) and share in total reserves (%)	Basic wood density timber, t/m^3[47]
Deciduous		
Beech	24170 (48%)	0.58
Chestnut	5792 (12%)	0.48
Alder	1426(3%)	0.45
Hornbeam	1009(2%)	0.74
Oak	715(1%)	0.66
Total	33112(66%)	
Basic wood density		**0.56**
Coniferous		
Fir	8386(17%)	0.415
Spruce	8051(16%)	0.44
Pine	298(0.6%)	0.48
Total	16735(34%)	
Basic wood density		**0.43**

To calculate basic, country-specific wood density the percentage distribution of the reserves of the dominating species was taken into consideration, see the Tables,. It should be mentioned, that the data for the species dominating incountries with a temperate climate, given in the Table attached to the IPCC "GPG LULUCF", closely match with the country-specific values for the dominating species in Georgia. In particular, in the GPG LULUCF, the basic wood density for deciduous (beech) equals to 0.58t/m^3, while for coniferous (fir) equals to 0.40t/m^3.

As for the relative volume used to calculate biomass decrease caused by different kinds of cutting timber resources, different types of cuttings and main species were used. As there does not exist data on species composition of produced wood, expert judgment decided the percentages of the main commercial and firewood species. Particularly, for commercial wood the study used beech-70%; pine-15%; spruce-10% and other-5%. For firewood, the following species were identified: beech-35%; hornbeam-30%; oriental hornbeam-20% and other-15%. According to the given percentages, the average value was calculated (see Table 7.11).

TABLE 7.11. ABSOLUTELY DRY VOLUME OF COMMERCIAL AND FIRE WOOD PRODUCED IN GEORGIA

Dominant forest species	Reserves of dominating species (m^3) and share in total reserves (%)	Basic wood density timber, t/m^3[48]
	Timber produced	
Beech	70	0.58
Spruce	15	0.48
Fir	10	0.41
Other	5	-
	100	

[47]Makhviladze. Timbers, Tbilisi 1962; Боровиков А.М., Уголев Б.Н.. Справочникподревесине. "ЛеснаяПромышленность", Москва, 1989;

[48]Makhviladze. Timbers, Tbilisi 1962; Боровиков А.М., Уголев Б.Н.. Справочникподревесине. "ЛеснаяПромышленность", Москва, 1989;

Dominant forest species	Reserves of dominating species (m^3) and share in total reserves (%)	Basic wood density timber, t/m^3[48]
Basic wood density		0.52
	firewood	
Beech	35	0.58
Hornbeam	30	0.74
Hophornbeam	20	0.74
Other	15	-
	100	
Basic wood density		**0.57**

The majority of the parameters indicated in the equations given in Fig 7.6 were taken from the GPG LULUCF Tables, and more specifically, values that refer to countries with temperate climate; the detailed parameters are listed in Table 7.12 indicating also the respective data source.

TABLE7.12 PARAMETERS USED IN INVENTORY AND THEIR VALUES

Factors	West Georgia		East Georgia		Autonomous Republic of Adjara		**Source**
	Deciduous	Coniferous	Deciduous	Coniferous	Deciduous	Coniferous	
CF- carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.);	0.5						Good Practice Guidance for Land Use, Land Use Change and Forestry, IPCC (2003)\
I_V- average annual net increment in volume suitable for industrial processing, m3 ha yr;	1.7	2.5	2.2	3.1	2.9	3.8	Statistical publication of Forestry Department 2006
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 3A1.10
R – root-to-shoot ratio appropriate to increments, dimensionless;	0.26	0.23	0.26	0.32	0.26	0.23	(IPCC 2003) Table 3A1.8
BEF_2 -biomass expansion factor for converting volumes of extracted roundwood to total aboveground biomass (including bark), dimensionless-	1.35						(IPCC 2003) Table 3A1.10
F_{BL}- fraction of biomass left to decay in forest (transferred to dead organic matter);	0.10						(IPCC 2003) Table 3A1.11
B_W- average biomass stock of forest areas, tonnes d.m. ha;	95	150	75	110	100	200	Statistical publication of Forestry Department 2006

Based on Forestry Department data for 2010-2013, several forest fire incidents took place in Georgia, which caused a loss of biomass. The respective volume values affected are included in the electronic Tables, while in Table 7.13 below, the area affected each year by forest fires is presented:

TABLE7.13. BURNT FOREST AREAS RECORDED IN GEORGIA IN 2010-2013[49]

Year	Burnt area (ha)					
	West Georgia		East Georgia		Adjara	
	Coniferous	Deciduous	Coniferous	Deciduous	Coniferous	Deciduous
2010	0.5	-	362.2	12.9	-	10
2011	-	-	-	7	-	-
2012	-	16.53	98.42	84	3	-
2013	12.1	7.21	13.1	55.2	5	2.5

As mentioned above, greenhouse gas emissions as a result of forest fires, was performed using the 3.2.20 equation[50].

Since country-specific values of the necessary factors to calculate accurately are not available in Georgia, the assessments for this source category were done following the GPG LULUCF Tier 1 methodology. The factors were taken from the Table 3A.1.12; Table 3A.1.13; and Table 3A.1.16. In particular, the values proposed for countries with a temperate climate were used:

C- Combustion efficiency factor = 0.45,

B- Fuel mass available on the area = 50.5t dry mass/ha

As for emission factors, their values are given in Table 7.14

TABLE 7.14 VALUES OF EMISSION FACTORS FOR INDIVIDUAL GREENHOUSE GASES

Gas	Emission Factors g/kg dry mass
CH_4	9.00
CO	130.00
N_2O	0.11
NO_X	0.70

For more accurate calculations compared to the last inventory, in forest covered areas in Georgia, which were merely divided in the moderately humid West and dry East , the separation of Adjarian Forestry Areas was added (based on information provided by the forestry agency). As a result weighted average indicators, to reduce variance, could be used. For instance, during the last inventory D, only dry wood volume weight was defined for both climate zones in Georgia: East Georgia, coniferous 0.45 t / m3, deciduous 0.65 t / m3; Western Georgia, coniferous 0.42t/m3, deciduous 0.55t/m3. Now, the Adjarian indicators were added: coniferous 0.43 t / m3, deciduous 0.56t/m3. It should be noted that the ratios of the 2003 IPCC best practices methodology table lies within the coefficient indicators set for temperate climate countries (LULUCF, Table 3A1.9-1) (deciduous to 0.58 t / m 3 is set , and for coniferous 0.40 t / m3).

7.3.3. EMISSIONS/REMOVALS CALCULATED IN FOREST LAND CATEGORY

Emissions and removals were calculated, and the respective worksheet tables were filled in, using the required activity data and emission factors for the inventory. According to the final

[49] National Forestry Agency http://moe.gov.ge/index.php?lang_id=GEO&sec_id=87

[50]Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 3,EQUATION 3.2.20. http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

results, carbon accumulation/deposition trend is demonstrated in Fig. 7.2. For reporting CO_2 emissions and removals, negative values show carbon accumulation, while positive values emissions, in accordance with the IPCC guidance. In the Tables below, the values are shown in accordance with this instruction of Guidelines. This applies to calculations carried out in all categories of land use.

TABLE 7.15 CARBON VOLUMES DEPOSITED IN COMMERCIAL FOREST LANDS IN GEORGIA

Year	Forest Land ha	Carbon Gains, thousand tonnes C	Carbon Lossesthousand tonnes C	Net Carbon Emssions/Removals, thousand t of C	Carbon Dioxide Emissions/Removals, 44/12 D Gg CO2
2010	1 960 690	1768.2	-377.5	1420.7	-5209.2
2011	1 960690	1768.2	-241.6	1526.5	-5597.2
2012	1 960 690	1768.2	-277.1	1491.1	-5467.4
2013	1 960 690	1 768.2	-267.5	1 500.7	-5 502.6

TABLE 7.16 ANNUAL ABSORPTION OF CARBON PER 1 HA OF FOREST LAND

Year	Carbon Absorption (taking into account losses), t C / ha	Carbon Dioxide Absorption, tCO2 / ha
2010	0.72	2.64
2011	0.78	2.86
2012	0.76	2.79
2013	0.39	1.43

TABLE 7.17 GHG EMISSIONS AS A RESULT OF FOREST FIRES IN COMMERCIAL FOREST LAND OF GEORGIA IN 2010-2013

Year	Greenhouse Gas Emission 10^{-3} Gg			
	CH_4	CO	N_2O	NO_X
2010	89.6	1294.6	1.1	7.0
2011	1.4	20.5	0.02	0.1
2012	59.1	854.2	0.7	4.6
2013	14.7	212.1	0.2	1.1

7.4. CROPLAND

7.4.1. DESCRIPTION OF SOURCE CATEGORY

The cropland category includes all agricultural lands (including areas covered by perennial crops), as well as all rested lands on which all works are temporarily suspended. Perennial crops include orchards, vineyards and plantations of different types. The cropland category also includes lands on which annual crops are grown, for further use as pastures.

The amount of carbon, accumulated on croplands, depends on the species grown on them, the management practices, and climate conditions. Annual crops (cereals, vegetables) are harvested each year; consequently, carbon is not accumulated in above ground biomass in the long term. In case of perennial crops (orchards, vineyards etc.), carbon is accumulated on an annual basis, which enables the development of carbon stock in the long run.

As for changes in carbon stocks in soils, practice of management of croplands, in particular on plowing land, drainage, the use of organic and mineral fertilizers, are crucial factors. In the case of using fertilizers, the emission of greenhouse gases is conducted according to Chapter 4 of separate work book Agriculture, provided in the IPCC Guidance[51].

The conversion of land of the other land use categories to cropland, might influence carbon stocks. Alteration of forest land, grassland and wetlands into croplands usually causes losses in carbon stocks; however, there is an exception, in particular alteration of the areas, where vegetation is scarce and, occasionally, the soil lacks biomass stocks, may result in an increase of carbon storage in croplands.

7.4.2. METHODOLOGY

a) Used method

The structure for developing a greenhouse gas inventory in accordance with the GPG LULUCF for this land use category is presented in Fig. 7.5.

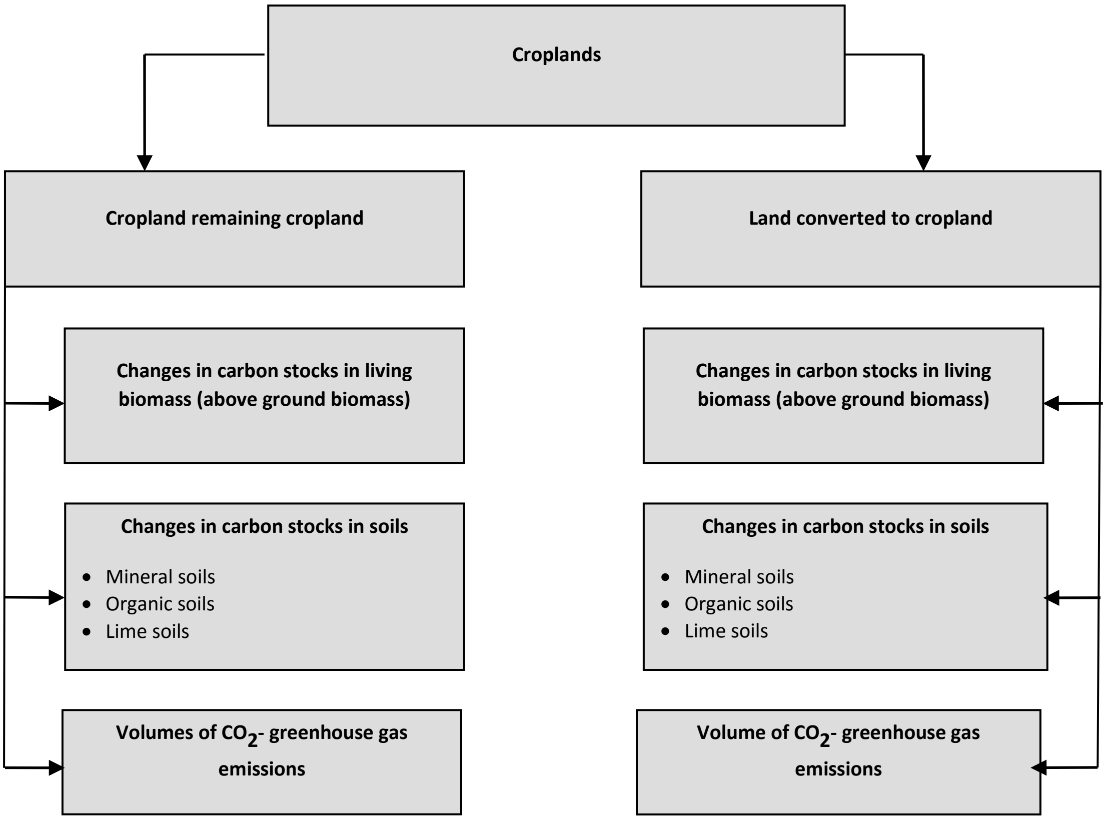


FIG.7.5 THE ESTIMATING STRUCTURE OF CROPLAND CATEGORY

The equation given below provides the basis for the method to calculate carbon stock changes in croplands remaining cropland category[52]:

$$\Delta C_{CC}=\Delta C_{CC_{LB}}+\Delta C_{CC_{soils}},$$

Where:

ΔC_{CC} - annual change in carbon stocks in cropland remaining cropland, tonnes C yr-1

$\Delta C_{CC_{LB}}$ - annual change in carbon stocks in living biomass, tonnes C yr-1

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[51]Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 4, Agriculture.http://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf

[52]Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 3, Cropland, EQUATION 3.3.1.http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

$\Delta C_{CC_{soils}}$ - annual change in carbon stocks in soils, tonnes C yr-1

According to the methodology, the cropland sector includes areas covered with perennial crops, for which changes in carbon in biomass are calculated. The carbon is accumulated in the biomass of perennial crops, such as orchards, vineyards etc. As for annual crops, since their harvest area is fully released from biomass annually, it is considered that carbon is not accumulated in the long term period, thus, carbon stock changes are assumed to be zero.

The magnitude of changes in carbon stock in biomass was calculated according to the methodology presented in the forest land category, in particular with the equation used for calculating changes in carbon stocsk in living biomass in "Forest land remaining forest land". According to the GPG LULUCF, it should be noted that calculations of perennial crops were made only for above ground biomass pool (no calculations have been made for below ground biomass pool).

The calculations for perennial crops (orchards) were conducted following the Tier 1 methodology, and the cropland area was further classified according to Georgia's climate zones. The calculations were carried out using the following method: on the areas covered by perennial crops the annual increase in carbon stocks is the result of the biomass growth, while annual decrease in carbon stocks is the result of biomass loss due to annual reduction of the planted area.

As for the calculation of carbon stock changes in soil organic matter, both mineral and organic soils were calculated. In addition, annual carbon emissions due to the agricultural lime application were estimated.

The changes in carbon reserves in soil were calculated with the following formula:

$$\Delta C_{CC_{soils}} = \Delta C_{CC_{mineral}} - \Delta C_{CC_{organic}} - \Delta C_{CC_{lime}}$$

Mineral soils

For mineral soils, the calculation methodology is based on changes in soil C stocks over a finite period following changes in management that impact soil carbon:

$$\Delta C_{CC_{Mineral}} = [(SOC_0 - SOC_{(0-T)}) \bullet A] / T,$$

$$SOC = SOC_{REF} \bullet F_{LU} \bullet F_{MG} \bullet F_I,$$

Where

$\Delta C_{CC_{mineral}}$ annual change in carbon stocks in mineral soils, tonnes C yr-1

SOC_0 -soil organic carbon stock in the inventory year, tonnes 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

Organic soils include dry peats on which agricultural activities are underway. When organic soils are dried (peat) and agricultural activities have started, oxidation of organic matters is stimulated and, as a result, carbon is released form the soil (emissions).

In Georgia, peat lands were dried in the 1960s. Due to the lack of data on relevant activities in 1992-2011, the calculations were not conducted.

Liming

The calculations include lime carbonates, for example limestone ($CaCO_3$), or dolomite ($CaCO_3$•$MgCO_3$), which are used in agriculture and are sources of CO_2 emission.

Humid subtropic soils, widespread in Georgia, are characterized with high acidity (pH=3,0-5,5). These soils are distinguished by physical and chemical features unfavorable for plants, due to which normal development of plants, absorption of nutrients and metabolism are limited. Harvest of annual crops, as well as of citruses and perennials, is very low on these soils. Thus, liming of those soils is needed to improve productivity.

In Georgia liming of acidic soils started in the 60s of the last century. Anually, lime application was implemented on around 10-12 thousand hectares, repeated once every 6-7 years, and was controlled by the government. Today, liming is rare, and there is no data available. In 2011, in Kakhati a village in the Zugdidi municipality, the company Nergeta started Kiwi plantations. During their activities, the company applied liming with a different intensity. Particularly, in 2011 it introduced lime on 14 ha, 2012 – 10 ha, and annually limes 3 ha.

In the cropland category, the following methodology is applied to estimate non-CO2 greenhouse gas emissions[53]:

- Assessment of N_2O emissions due to the use of mineral and organic fertilizers (IPCC Guidelines: chapter 4 "Agriculture");
- Assessment of N2O, NOx, CH4 and CO emissions from on-site and off-site biomass burning (IPCC Guidelines: chapter 4 "Agriculture");
- Assessment of N_2O emissions, due to cultivation of organic soils (drying peats).

Carbon stock changes, and non-CO2 greenhouse gas emissions for other land use categories converted to cropland, were not assesed due to a lack of necessary activity data in Georgia. It should also be mentioned, that various agency surveys determined that different categories of areas of arable parcels of arable land transferred to large-scale facts, as well as the area (hereinafter referred to agricultural use) in a large seizure, did not occur. Therefore, it can be said that the occurred changes in the Figures are not available.

[53]Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 4, Agriculture.http://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf

b) Activity data

In 2010 – 2013, the Georgia cropland area distribution in the different climate regions is presented below, in Table 7.18.

TABLE 7.18 CROPLAND AREA[54]

Year	Georgia Climate Zones	Total, thousand ha	Arable Land, thousand ha	Perennial Plantations, thousand ha
2010	1. East Georgia, temperate warm and dry	375	305	70
	2. West Georgia, temperate warm, humid	165	110	55
Total		540	415	125
2011	1. East Georgia, temperate warm and dry	365	295	70
	2. West Georgia, temperate warm, humid	162	107	55
Total		527	402	125
2012	1. East Georgia temperate warm and dry	363	293	70
	2. West Georgia, temperate warm, humid	162	107	55
Total		525	400	125
2013	1. East Georgia, temperate warm and dry	395	325	70
	2. West Georgia, temperate warm, humid	181	126	55
Total		576	451	125

c) Emission factors

According to Table 3.3.2 of the GPG LULUCF, data referring to a temperate climate was used to calculate carbon stock changes in perennial croplands in Georgia. In particular, the biomass accumulation in above ground biomass were taken equal to 2.1 t C/year, while in 1 ha perennial croplands 63t of carbon is accumulated at harvest (according to the methodology, this value applies both to moderately warm humid and dry climates). The losses are calculated every year, following the reduction of the areas covered by croplands (death or cut). In this case, it is assumed that accumulated carbon is released to the atmosphere. The carbon losses (1ha = 63tC) are deducted from carbon expansion in perennials (1ha =2.1tC/year), which are caused by the reduction of the areas. According to the data for 2010-2013, no changes in the area of perennial plantations were identified, remaining steady (125 ha).

The respective emission factors for the two different climate zones (West humid and East dry) were applied to calculate carbon stock changes in soils. Consequently, according to the soil classification given in Table 3.3.3 of the Guidelines, different reference carbon stocks values in soils were applied.

For mineral soils, calculating the change of carbon stock Tier 1 was used. Thus, the default values of emission factors were taken from the Tables given in the Guidelines[55]: Table 3.3.3 and Table 3.3.4.

[54] FAO (Food and Agriculture Organization) statistical data 1992-2011; http://www.fao.org/statistics/en/

TABLE7.19. EMISSION COEFFICIENTS 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		according to the Methodology the admissibility determination of the coefficients
	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, tonnes C ha	63	38	63	38	soil map was used[56]
F_{LU} - stock change factor for land use or land-use change type, dimensionless	0.71	0.82	0.71	0.82	Represents area that has continuously been managed for >20 yrs, to predominantly annual crops.
F_{MG} - stock change factor for management regime, dimensionless	1	1	1.09	1.03	Admissibility of a management regime for Georgia
F_I - stock change factor for input of organic matter, dimensionless	0.91	0.92	0.91	0.92	Low residue returns due to the removal of residues

7.4.3. CALCULATED EMISSIONS

Since the calculations were made following the Tier 1 approach and the default data given in the methodology apply to all temperate climate areas (including all temperate dry or humid climate), calculatiosn were done only for perennial crops areas in Georgia as a whole. The changes in carbon stocks, which took place during 2010-2013. are given in Table 7.20:

[55]Good Practice Guidance for Land Use, Land-Use Change and Forestry,Chapter 3, Cropland, Table 3.3.3; Table 3.3.4.http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

[56] http://agromarket.ge/soil_maps/data/georgia_soil_map.pdf

TABLE 7.20 CHANGES IN CARBON STOCK IN THE BIOMASS OF PERENNIALS

Year	Area thousand ha	Reduction of areas compared to previous year, thousand ha	Carbon accumulation, thousand t C	Losses, thousand t C/year	Net annual carbon stock change in cropland, thousand t C/year	Net annual carbon dioxide emissions/removals in cropland, $GgCO_2$ /year
2010	125	-	262.5	-	262.5	-962.5
2011	125	-	262.5	-	262.5	-962.5
2012	125	-	262.5	-	262.5	-962.5
2013	125	-	262.5	-	262.5	-962.5

Regarding the estimation of carbon stock changes in mineral soils in croplands, as it was already mentioned the respective emission factors were taken from the IPCC Guidelines Tables.

According to IPCC guideline instructions above mentioned number CO_2 take up/emission should be included in the final summed Table with (-) symbol (see Table 7.22):

TABLE 7.21 CARBON STOCK CHANGES AND CO2 EMISSIONS/REMOVALS IN CROPLANDS (IN MINERAL SOILS)

Year	Climate zone	Area, thousand ha	Inventory year (SOC_0) t Cha/year	20 years prior to the inventory ($SOC_{(0-T)}$) – t Cha/year	Annual change in carbon stocks in mineral soils thousand t C/year	Carbon dioxide emissions $GgCO_2$/year
2010	Temperate warm dry	375	28.7	29.5	16.2	-59.4
	Temperate warm, humid	165	40.7	44.4	30.2	-110.7
Total		540	69.4	73.9	46.4	-170.1
2011	Temperate warm dry	365	28.7	29.5	12.7	-46.5
	Temperate warm, humid	162	40.7	44.4	19.6	-71.8
Total		402	69.4	73.9	32.3	-118.4
2012	Temperate warm dry	363	28.7	29.5	12.9	-47.3
	Temperate warm, humid	162	40.7	44.4	18.3	-67.1
Total		400	69.4	73.9	31.2	-114.4
2013	Temperate warm dry	395	28.7	29.5	14.5	-53.1
	Temperate warm, humid	181	40.7	44.4	20.8	-76.3
Total		451	69.4	73.9	35.3	-129.4

TABLE 7.22. CO_2, EMISSIONS, DUE TO LIME APPLICATION

Year	Type of lime applied in the area	Limed area, ha	Amount of limestone applied to the area t limestone/year	Emission factor, tC/t limestone	Carbon dissipation as a result of liming, T C/year	CO_2 emission 10^{-3} Gg/year
2010	Limestone $CaCO_3$	-	-	-	-	-
2011	Limestone CaCO3	14	70	0.12	8.4	30.8
2012	Limestone CaCO3	10	50	0.12	6	22.0
2013	Limestone CaCO3	3	15	0.12	1.8	6.6

7.5. GRASSLAND

7.5.1. DESCRIPTION OF SOURCE CATEGORY

Grasslands differ based on the quality and intensity of their management. A grassland maintenance regime means keeping intensity of grazing, application of fertilizers, irrigation. Besides, it is possible to use the pastures as grasslands, which completely changes the system for grasslands management. Unsystematic grazing, fires and land erosion have a negative impact on grasslands, which finally impact carbon stocks. When these impacts are significant, and carbon is not further accumulated, grasslands become an emission source.

7.5.2. METHODOLOGY

a) Used method

In grasslands below ground, carbon stocks are higher than above ground stocks. Carbon stocks are basically accumulated in the root systems and the organic matter of soil. This is illustrated in Fig. 7.6, which provides the structure for the development of the greenhouse gas inventory[57]in this source category.

[57]Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 3, GRASSLAND.http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

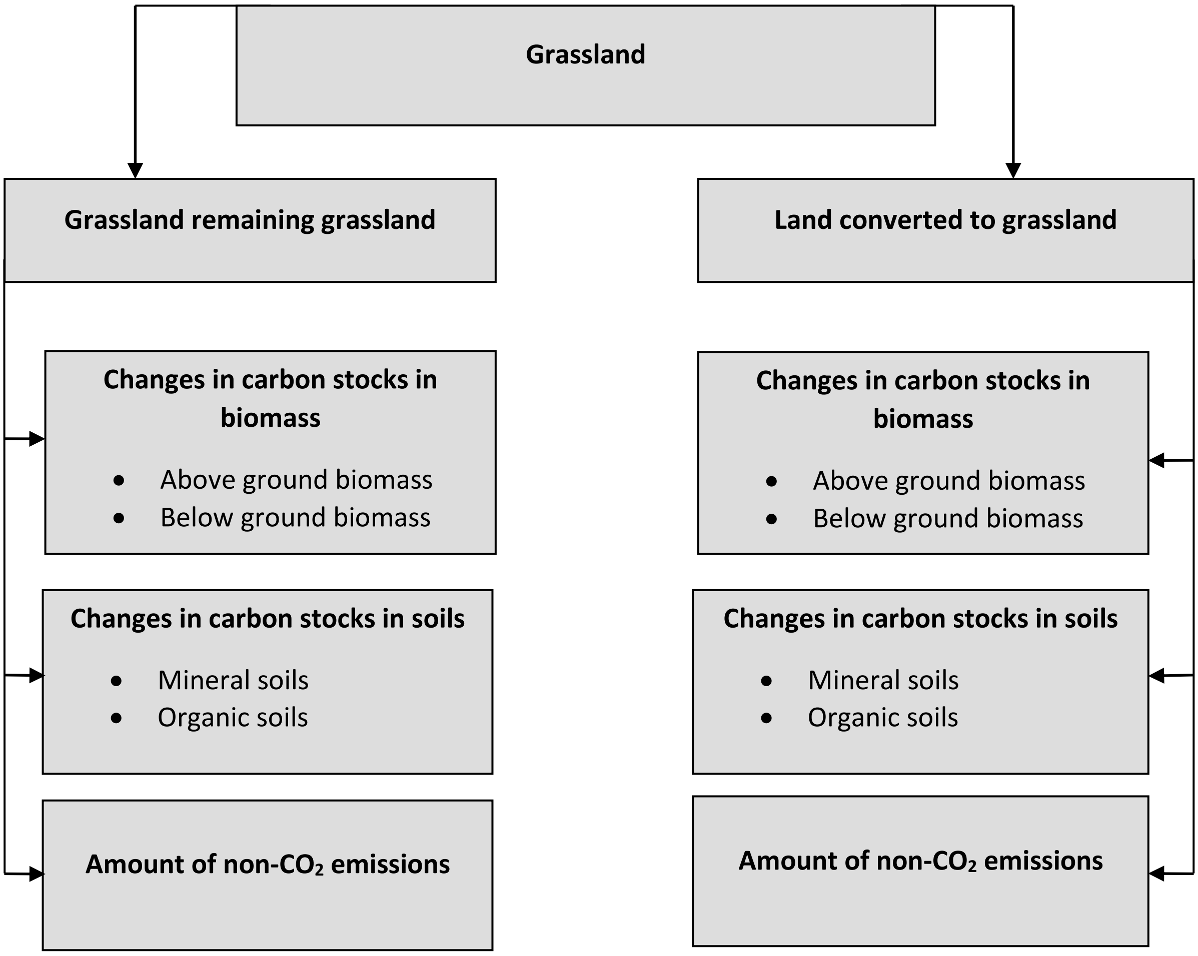

FIG.7.6 METHODOLOGICAL STRUCTURE OF GREENHOUSE GAS INVENTORY IN GRASSLAND

Carbon stocks existing in grasslands are influenced by human activities and natural disturbances. The annual accumulation of biomass on pastures might reach a high volume, but due to rapid outflow (grazing, mowing, and fires etc), biomass stocks per hectare usually do not exceed a few tonnes.

The calculations were conducted following the Tier 1 approach. Taking this into consideration, the calculations were made similarly, in accordance with the equations given for croplands[58], using the respective Table for grasslands for the emission factors.[59] Following the Tier 1 approach, it is assumed that management practices are static over time, and thus, biomass carbon stocs are in an approximate steady-state. Consequently, there is no change in living biomass carbon stocks.

Despite the fact that the grassland category includes pastures and hay lands, the regime of their management is radically different. Thus, calculations were undertaken separately for pastures and haylands.

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[58]http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html(equi. 3.3.3.);
[59]Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 3, GRASSLAND, Table 3.4.5.http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html.

Mineral soils

The formula for calculating the changes in carbon stock in mineral soils is given below:

$$\Delta C_{GG_{Mineral}} = [(SOC_0 - SOC_{(0-T)}) \bullet A] / T,$$

$$SOC = SOC_{REF} \bullet F_{LU} \bullet F_{MG} \bullet F_I,$$

Where:

$\Delta C_{GG_{Mineral}}$ = annual change in carbon stocks in mineral soils, tonnes C yr-1

SOC_0 = soil organic carbon stock in the inventory year, tonnes 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

The calculations for grasslands and haylands on organic soils were conducted in case of draining activities. It was already mentioned above that the area of dried land is presently unknown in Georgia. Consequently, calculations were not carried out due to lack of necessary data.

It should be noted that also due to lack of data on liming grasslands and haylands (area of limed grasslands) the calculations were conducted in this field either.

The sources of non-CO2 greenhouse gas emission are discussed in subcategory Agriculture of the IPCC Methodological Guidelines:

- N2O emissions from application of mineral and organic fertilisers, organic residues and biological nitrogen fixation in managed grassland;
- N2O, NOx, CH4 and CO emissions from grassland (savanna) burning in the tropics; and
- CH4 emissions from grazing livestock.

b) Activity data

The distribution of hay lands and grasslands in two Georgian regions with different climates, is given in Table 7.23

TABLE 7.23 HAYLAND AND GRASSLAND AREAS

Years	Climate zones of Georgia		Hay land thousand ha	Grassland thousand ha
2010	Temperate warm, dry	1323.3	96.4	1226.9
	Temperate warm, humid	616.7	39.4	577.3
	Total	1940	135.8	1804.2
2011	Temperate warm, dry	1323.3	96.4	1226.9
	Temperate warm, humid	616.7	39.4	577.3
	Total	1940	1940	135.8
2012	Temperate warm, dry	1323.3	96.4	1226.9
	Temperate warm, humid	616.7	39.4	577.3
	Total	1940	1940	135.8
2013	Temperate warm, dry	1323.3	96.4	1226.9
	Temperate warm, humid	616.7	39.4	577.3
	Total	1940	1940	135.8

c) Emission factors

Since the calculations for soils were conducted following Tier 1 approach, the values for the different parameter were taken from the Tables given in the Guidelines; (Table 3.4.4. and Table 3.4.5),[60] the factors proposed for temperate dry and temperate humid climate zones were used.

The default values for reference carbon stock for grasslands, according to the Table 3.4.4: for temperate humid and temperate dry climate zones 63tC/ha and 38tC/ha were taken respectively. Since the pastures are significantly degraded in Georgia, the stock change factor for the management regime corresponding to sharp degradation were used (F_{MG}) for East Georgia, while for West Georgia – the factor corresponding to average degradation was used.

Haylands are less degraded compared to grasslands and, consequently, are more stable. Hence, different factors (for less degradation) were taken into account.

TABLE 7.24. EMISSION COEFFICIENTS USED IN CALCULATIONS

Emission Factors	SOC(0-T) - soil organic carbon stock T years prior to the inventory, tonnes C ha-1;		SOC0- soil organic carbon stock in the inventory year, tonnes 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, tonnes C ha	63	38	63	38
F_{LU} - stock change factor for land use or land-use change type	1	1	1	0.95

[60]Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 3, GRASSLAND, Table 3.4.4; Table 3.4.5.

F_{MG} - stock change factor for management regime	1	1	0.95	0.7
F_I - stock change factor for input of organic matter	1	1	1	1

7.5.3. CALCULATED EMISSIONS

As mentioned above, the calculations were conducted using the equation for the cropland category. The calculations demonstrated that the condition of haylands is stable and emissions do not take place, while the grasslands act as a source of emission. For example, out of the total area of grasslands in Georgia (1 940 thousand ha), the pastures of East Georgia are spread on 1 214 thousand ha, while the pastures of West Georgia- on 726 thousand ha. The order of calculations in grassland and hayland soils is given below:

$$\Delta C_{CC_{Mineral}} = [(SOC_0 - SOC_{(0\text{-}T)}) \bullet A] / T,$$

$$SOC = SOC_{REF} \bullet F_{LU} \bullet F_{MG} \bullet F_{I},$$

East Georgia (grassland):

$$\Delta C_{CC_{Mineral}} = [(38\times1\times0.7\times1-38\times1\times0.95\times1)\times1\ 226\ 900]/20 = -582\ 777\ \text{tC/year}$$

West Georgia:

$$\Delta C_{CC_{Mineral}} = [(63\times1\times0.95\times1-63\times1\times1\times1)\times577\ 300]/20 = -90\ 924\ \text{tCyear}$$

According to above mentioned instructions, the total value is included in the final report with positive symbol, since it indicates carbon emission to the atmosphere. Thus, for the last decade, Table 7.25 $\Delta C_{CCmineral}$= 673.7 thousand tC/year.

TABLE 7.25 CARBON EMISSIONS FROM MINERAL SOILS IN GRASSLANDS AND HAYLANDS

Year	Area, thousand ha	Inventory year (SOC_0) t Cha/year	20 years prior to the inventory ($SOC_{(0-T)}$) – t Cha/year	Annual change in carbon stocks in mineral soils thousand t C/year	Carbon dioxide emissions $GgCO_2$/year
2010	1940.0	187.4	200.1	-673.7	2 470.2
2011	1940.0	187.4	200.1	-673.7	2 470.2
2012	1940.0	187.4	200.1	-673.7	2 470.2
2013	1940.0	187.4	200.1	-673.7	2 470.2

Since information about the conversion of lands of different categories (forest lands, wetlands and so on) into grasslands is not available, the corresponding calculations were not conducted. Finally, as a result of the survey, it was determined that no large scale conversion of the lands of different categories into grasslands or capturing the lands for using as grasslands, took place.

7.6. WETLANDS

The wetland category includes the lands, which are saturated or covered with water throughout the year. These areas are not part of forest land, crop lands, grasslands - haylands or settlements categories.

According to the Guidelines, this category is divided into "wetland remaining wetland category" and "the land converted to wetland". Calculations for wetlands are done to define emissions as a result of developing peat and drying wetlands. In this subsector due to a lack of data, calculations were not carried out.

7.7. SETTLEMENTS

The settlements category includes all areas used by the population, transport infrastructure, and small size settlements. For this category, the inventory was conducted for the crops available in settlements (along the roads, in the yards). The lack of data is indicated in the methodology and, consequently, default data respective to the countries are given by climate zones.

Since the data necessary to calculate the inventory were not found in Georgia, calculations were not carried out. Missing data: on the areas covered by timber plants (ha) in all settlements (cities, villages and settlements), by years, as well as on the volume of annual accretion of carbon in given crops (toneC/year), and average age of timber plants in composition of cover (year).

7.8. OTHER LAND

The category of other land includes all areas which are lacking vegetation and do not fall within the other land use categories: rocks, glaciers etc. According to the methodology, calculations are not done for this category, since it is considered that these are typical unmanaged areas. As for the lands converted into other land category (forest lands, wetlands and so on), a lack of the necessary activity data, resulted in not being able to conduct carbon stock change estimation.

8. WASTE

8.1. SECTOR OVERVIEW

The treatment of waste has become a serious environmental concern and Municipal Solid Waste (MSW) management continues to be an important environmental challenge for Georgia.

Currently, there is no acceptable state inventory system for waste in Georgia. Therefore, data on the annually generated amounts of wastes, waste types, disposal and utilization, are practically absent. Very limited data is scattered among different agencies. The data is not digitized and accessible to different users. Comprehensive waste inventories have not yet been conducted, nor was a state register established, which should include waste catalogue, inventories of wastes and their disposal sites, as well as databases on wastes and technologies of their utilization and rendering harmless.

In Georgian cities, municipal waste is collected and transported to landfills for disposal. However, there are no reliable statistics on the generation of MSW. There is no reliable information on the composition of waste, although it is clear that the share of paper and plastics has increased.

Adding to the current problems of outdated waste collection and disposal facilities is the potential for waste generation rates to increase in Georgia with the anticipated economic growth in the future. It is expected that MSW will grow rapidly when consumption connected with higher incomes increases. The waste stream could also change, with more packaging leading to the generation of new and different types of waste. The problem is particularly serious in cities. Given the potential for higher waste generation rates, it is important that Georgia develops modern recycling systems, including household waste separation, to reduce the amount of waste being disposed off at dump sites. At present, there are no facilities for separating, processing and recycling plastics, paper and glass from municipal waste.

Waste management and climate change are closely related. Management of municipal solid waste presents many opportunities for greenhouse gas (GHG) emission reductions. Source reduction and recycling can reduce emissions at the manufacturing stage, increase forest carbon storage, and avoid landfill methane emissions. Combustion of waste allows energy recovery to displace fossil fuel-generated electricity from utilities, thus, reducing GHG emissions from the utility sector and landfill methane emissions. Diverting organic materials from landfills also reduces methane emissions.

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 derogate gravely the natural environment, flora and fauna, and the quality of life of population. Phreatic water resources are polluted, which has repercussions on agricultural products and finally on the people. Since 1991, after collapse of the Soviet Union, political and economic events in Georgia resulted in the devaluation of many sectors, including the municipal Waste and Wastewater (W&WW) sector. Despite the stabilization of economic situation in the country, the W&WW sector still faces problems.

The centralized sewage system exists in 45 towns in Georgia. About 80% of the population is connected to sewerage, indicating high network penetration by international standards. The

systems are, however, in poor condition. The plants are typically 20-35 years old; some are as yet unfinished, and most are not maintained. Most of the wastewater treatment plants (WWTP) cannot provide sewage treatment with high efficiency. None of the existing plants is actually providing biological treatment, since the technical facilities are out of order. Nationally, there is only one fully operational WWTP in Sachkhere. Another, in Gardabani, provides only primary, mechanical treatment. The Gardabani WWTP receives municipal wastewaters from the capital of Georgia Tbilisi, and the city of Rustavi. However, a significant volume of untreated urban wastewater from Tbilisi and Rustavi discharges directly into the Mtkvari River. Construction projects for a biological wastewater treatment facility for Batumi and the coastal settlements from Batumi to the Turkish boarder, as well as for the city of Poti have already been developed.

The estimated GHG emissions from the waste sector for 2010-2013 are given in Table 8.1. In the same Table, methane emissions from the waste sector in 2010s preceding years, from the Third National Communications (TNC) of Georgia to the UNFCCC, are also presented. According to this Table, the differences between the two inventories for 2010 and 2011 constitutes accordingly 6.5% and 6.4%. Differences are caused mainly due to applied, more precise, data provided by National Statistic Office of Georgia and Solid Waste Management Company of Georgia; and the latest FAO per capita protein consumption data for Georgia.

TABLE 8.1: GHG EMISSIONS FROM WASTE SECTOR IN THOUSAND TONNES

Gas/Source	1990	1994	2000	2005	2010	2011	2012	2013
CH_4 / Solid Waste Disposal Sides (BUR)					41.1	41.6	41.7	41.9
CH_4 / Solid Waste Disposal Sides (TNC)	35.9	37.0	38.1	38.6	*39.9*	*40.3*		
Difference, in %					*3.0*	*3.3*		
CH_4 / Industrial W/W Handling (BUR)					1.4	1.6	2.2	2.1
CH_4 / Industrial W/W Handling (TNC)	*11.0*	*0.0*	*0.4*	*0.8*	*0.8*	*0.8*		
Difference, in %					*76.6*	*111.7*		
CH_4 / Domestic Waste Water Handling (BUR)					11.0	11.1	11.1	11.2
CH_4 / Domestic Waste Water Handling (TNC)	9.6	9.3	8.8	8.7	*9.9*	*10.4*		
Difference, in %					*10.9*	*6.6*		
N_2O / Domestic Waste Water Handling (BUR)					0.33	0.33	0.34	0.34
N_2O /Domestic Waste Water handling (TNC)	0.15	0.16	0.15	0.16	*0.17*	*0.17*		
Difference, in %					*23.5*	*24.1*		
CO_2eq Emissions from Waste Sector (BUR)					*1,226*	*1,243*	*1,260*	*1,265*
CO_2eq Emissions from Waste Sector (TNC)	*1,232*	*1,021*	*1,040*	*1,057*	*1,114*	*1,133*		
Difference, in %					*10.0*	*9.7*		

The share of GHG emissions from the waste sector varies between 2.9-11.3%. The share of different sources in the National GHG emissions are presented in Table 8.2.

TABLE 8.2: SHARE OF DIFFERENT SOURCES FROM WASTE SECTOR IN NATIONAL GHG EMISSIONS

Gas/Source	1990	1994	2000	2005	2010	2011	2012	2013
CH_4 / Solid Waste Disposal Sides	1.6	8.8	7.4	6.7	6.7	5.5	5.1	5.3
CH_4 / Industrial Waste Water Handling	0.5	0.0	0.1	0.1	0.2	0.2	0.3	0.3
CH_4 / Domestic Waste Water Handling	0.4	2.2	1.7	1.5	1.8	1.5	1.4	1.4
N_2O / Domestic Waste Water Handling	0.1	0.6	0.4	0.4	0.8	0.6	0.6	0.6
Total CO_2eq	2.6	11.6	9.6	8.7	9.5	7.8	7.3	7.5

8.2. GHG EMISSIONS FROM SOLID WASTE DISPOSAL SITES (SWDS)

The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (hereafter 1996 IPCC) and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (hereafter IPCC GPG) described two methods for estimating CH4 emissions from SWDS: the mass balance method (Tier 1) and the First Order Decay (FOD) method (Tier 2). The 2006 IPCC strongly discourages the use of the mass balance method, as it produces results that are not comparable with the FOD method, which produces more accurate estimates of annual emissions.

In order to calculate methane emissions from landfills of Georgia, the First order decay (FOD) method is used. The 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 formed. If conditions are constant, the rate of CH4 production depends solely on the amount of carbon remaining in the waste. As a result, emissions of CH4 from waste deposited in a disposal site are highest in the first few years after deposition, then gradually decline as the degradable carbon in the waste is consumed by the bacteria responsible for the decay.

First order decay (FOD) method

$$CH_{4\ generated,t} = \{ DDOCm_t \bullet [1 - \exp(-k)] + H_{t-1} \bullet [1 - \exp(-k)] \} \bullet 16/12 \bullet F_t$$

$$H_t = DDOCm_t \bullet \exp(-k) + H_{t-1} \bullet \exp(-k), \quad H_o = 0$$

$$DDOCm_t = W_t \bullet DOC_t \bullet DOCF_t \bullet MCF_t$$

$$W_t = Pop_t \bullet GR_t \bullet MSW_{F,t}$$

Where

$CH_{4\ generated,t}$	generated CH_4 in year t
t	year of inventory
$DDOCm_t$	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

Georgia's solid waste management company provided the data on the amount of waste annually deposited in landfills.

Methane correction factor (MCF). MCF accounts for the fact that unmanaged SWDS produce less CH4 from a given amount of waste, than managed SWDS, as a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS.

TABLE 8.3: 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

There are more than 60 landfills in Georgia. In 14 unmanaged landfills, the waste layer is very shallow and actually methane is not generated. In 12 cities with population more then 50,000, habitant landfills are managed. Based on information about unmanaged landfills in towns and settlements, two hypothetic unmanaged landfills are considered incorporating all these landfills. In order to calculate methane emissions the (simplifying) assumption was made that all the waste from unmanaged landfills with shallow waste layer (<5m) are disposed on hypothetic landfill I, and wastes from unmanaged landfills with deep waste layer (>=5m) are disposed on another hypothetic landfill II.

Waste composition: There is very scarce information about the composition of solid waste disposed in landfills of Georgia. Default values (for Eastern Europe region) from the 2006 IPCC were used.

TABLE 8.4: WASTE COMPOSITION

Component \ source	Percent
Second Food	30.1
Broad Definition for Mixed Paper	21.8
Textiles	4.7

Wood	7.5
Leather	1.4
Other	34.0

Degradable organic carbon (DOC) is the portion of organic carbon present in solid waste that is susceptible to biochemical decomposition. For DOC values of specific materials, data from laboratory experiments conducted by Dr.Barlaz[61] were used. 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 8.5. Data from this Table was used to calcultae DOC containing in k component (DOC $^{k}{}_{p}$) of waste and DOC in total.

$$DOC\ ^{k}{}_{p} = DOC\ ^{k}{}_{100\%} \bullet P/100; \qquad DOC = \sum_k DOC\ ^{k}{}_{p}$$

Calculated **DOC=0.1884**.

TABLE 8.5: DOC FOR WASTE COMPONENTS

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**

The fraction of degradable organic carbon dissimilated (DOC_F) is the portion of DOC that is converted to landfill gas. It is 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[62] and data from Barlaz's experiment were used. The DOC_F for mix of materials (municipal solid waste) was calculated by the formula:

$$DOC_F = \sum_k (DOC_k \bullet DOC_{Fk}) \ / \ DOC$$

Results are presented in Table 6.6. **DOC_F =0.5208**(=0.0981/0.1884).

[61] 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.

[62] http://compost.css.cornell.edu/calc/lignin.html#txt24 http://compost.css.cornell.edu/calc/lignin.html#txt24

TABLE 8.6: ESTIMATED DOC_F

	DOC_i	$DOCF_i$	DOC_i*$DOCF_i$	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	
$\sum$	0.1884		0.0981	**0.5208**

Fraction of CH_4 in landfill gas (F): To calculate the fraction by volume of CH_4 in landfill gas, the Extended Buswell Equation[63] was used. Estimated **F=0.5308**.

Half life ($t_{1/2}$): For all the considered cities, the mean annual temperature is less than 20^{0}C and consequently, in terms of the 2006 IPCC, the climate zone is Boreal and Temperate. For cities located in Western Georgia the parameter is MAP/PET > 1. For this case, the recommended default methane generation rate is k=0.09 ($t_{1/2}$=7.7). For cities in Eastern Georgia: k=0.06 ($t_{1/2}$=11.55).

Emissions

For comparison, calculations were carried out applying the mass balance method (tier 1) as well. Results are given in Table 8.7.

TABLE 8.7: COMPARISON OF TIER 2 AND TIER 1 APPROACHES

	2010	2011	2012	2013
Methane Emissions in GG, Tier 1	41.0	42.8	42.8	43.2
Methane Emissions in GG, Tier 2	41.1	41.6	41.7	41.9
Difference in %	0.2	-2.9	-2.6	-3.1

In table 8.8, estimated methane emissions from the SWDSs of Georgia are given.

[63] Buswell A.M., Hatfield W.D. (ed.) (1937): Anaerobic Fermentations. State of Illinois, Department of Registration and Education, Bulletin No. 32.

TABLE 8.8: METHANE EMISSIONS FROM SWDSS OF GEORGIA

Year	Tbilisi				Kutaisi	Rustavi		Batumi	Gori	Poti	Zugdidi		Hypothetic		GHG Emissions	
	Norio	Gldani	Lagludji	Lilo			New					New	I (MCF=0.4)	II (MCF=0.8)	$GgCH_4$	$GgCO_2eq$
1987		10.8	1.1		3.1	1.2		3.3	0.1	1.0			1.1	0.4	**22.0**	**461**
1988		11.6	1.6		3.2	1.2		3.3	0.1	1.1			1.2	0.4	**23.7**	**499**
1989		12.4	2.2		3.3	1.2		3.4	0.1	1.1			1.2	0.5	**25.4**	**534**
1990		12.8	2.7	0.3	3.4	1.3		3.5	0.2	1.1			1.3	0.6	**27.0**	**566**
1991		13.1	3.1	0.5	3.4	1.3		3.6	0.2	1.1			1.4	0.6	**28.5**	**598**
1992		13.5	3.6	0.7	3.5	1.3		3.7	0.2	1.1			1.5	0.7	**29.8**	**627**
1993		13.8	4.1	1.0	3.6	1.3		3.8	0.2	1.1			1.6	0.7	**31.1**	**653**
1994		14.1	4.5	1.1	3.6	1.2		3.9	0.2	1.2			1.6	0.8	**32.1**	**675**
1995		14.3	4.8	1.4	3.7	1.1		3.9	0.3	1.2			1.7	0.8	**33.2**	**697**
1996		14.5	5.2	1.6	3.7	1.0		4.0	0.3	1.2			1.7	0.8	**34.1**	**716**
1997		14.7	5.5	1.7	3.8	1.0		4.1	0.3	1.2			1.8	0.9	**34.8**	**732**
1998		14.8	5.7	1.9	3.8	0.9		4.1	0.3	1.2			1.8	0.9	**35.5**	**745**
1999		14.9	5.9	2.1	3.8	0.9		4.1	0.3	1.2			1.9	0.9	**36.0**	**756**
2000		15.0	6.1	2.2	3.8	0.8		4.1	0.3	1.2	0.01		1.9	1.0	**36.5**	**767**
2001		15.1	6.3	2.3	3.8	0.8		4.2	0.3	1.2	0.03		1.9	1.0	**37.0**	**777**
2002		15.2	6.5	2.4	3.8	0.7		4.2	0.4	1.2	0.04		2.0	1.1	**37.5**	**787**
2003		15.2	6.6	2.5	3.8	0.7		4.2	0.4	1.2	0.05		2.0	1.1	**37.8**	**795**
2004		15.3	6.8	2.6	3.8	0.6		4.2	0.4	1.2	0.06		2.1	1.1	**38.2**	**802**
2005		15.7	6.9	2.5	3.8	0.6		4.2	0.4	1.2	0.07		2.1	1.2	**38.6**	**811**
2006		16.1	7.1	2.3	3.8	0.6		4.2	0.4	1.2	0.07		2.2	1.2	**39.1**	**821**
2007		16.4	7.2	2.2	3.8	0.5		4.2	0.4	1.2	0.08		2.3	1.2	**39.6**	**831**
2008		16.7	7.4	2.1	3.8	0.5		4.2	0.4	1.2	0.1		2.3	1.3	**40.1**	**842**
2009		17.1	7.5	2.0	3.8	0.5		4.2	0.4	1.3	0.1		2.4	1.4	**40.6**	**853**
2010		17.4	7.7	1.8	3.8	0.5		4.2	0.4	1.3	0.1		2.5	1.4	**41.1**	**863**
2011		17.7	7.9	1.7	3.8	0.4		4.3	0.4	1.3	0.1	0.03	2.6	1.5	**41.6**	**874**
2012	1.5	16.7	7.4	1.6	3.8	0.4	0.1	4.3	0.4	1.3	0.1	0.1	2.7	1.5	**41.7**	**876**
2013	2.8	15.7	7.0	1.5	3.8	0.4	0.2	4.3	0.4	1.3	0.1	0.1	2.7	1.6	**41.9**	**879**

8.3. WASTEWATER HANDLING

The water used in households and industry contains a vast amount of toxins which gravely deteriorate the natural environment, flora and fauna, and the quality of life of population. Phreatic water resources are polluted, which has consequences for agricultural products, and the population as well. Wastewater handling systems transfer wastewater from its source to a disposal site. Wastewater treatment systems are used to biologically stabilize the wastewater before disposal. In the first stage of the wastewater treatment (primary treatment), larger solids are removed from the wastewater. Remaining particulates are then allowed to settle. In the next stage, the treatment consists of a combination of biological processes which promote biodegradation by microorganisms. Industrial wastewater is either treated on site, or released into domestic sewer systems. Methane emissions from on-site industrial wastewater treatment are considered only.

Sludge is produced in both stages of the treatment. Sludge produced in the primary treatment, consists of solids that are removed from the wastewater. Sludge produced in secondary treatment is a result of biological growth in the biomass, as well as the collection of small particles. This sludge must be treated further before it can be safely disposed off. Methods of sludge treatment include aerobic and anaerobic stabilization (digestion), conditioning, centrifugation, composting, and drying.

When wastewater or sludge is treated, anaerobically CH_4 is produced. Methane emissions from aerobic systems are negligible. Wastewater treatment systems generate N_2O through the nitrification and denitrification of sewage nitrogen.

Mainly anaerobic methods are used to handle wastewater from the municipal sewage and from industrial facilities. A common practice is wastewater treatment in an anaerobic open lagoons system, without methane recovery from either wastewater or sludge treatment.

8.3.1.DOMESTIC & COMMERCIAL WASTEWATER TREATMENT

Methodological issues: CH4 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). Biochemical oxygen demand, or BOD, is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period. The BOD concentration indicates only the amount of carbon that is aerobically biodegradable. Chemical oxygen demand (COD) is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite. The COD measures the total material available for chemical oxidation (both biodegradable and non-biodegradable).

The methane generation depends also 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 a temperature higher than 15°C.

To estimate the total emissions from wastewater, the selected emissions factors are multiplied by the associated organic wastewater production and summed.

The following equation was used

$$WM = \sum_i (TOW_i \bullet EF_i - MR_i)$$

Where

WM total methane emissions from wastewater in $kgCH_4$;

TOW_i total organic waste for wastewater type i in kg BOD/yr;

EF_i emission factor for wastewater type i in $kgCH_4$/kgBOD;

MR_i total amount of methane recovered or flared from wastewater type i in $kgCH_4$.

The total domestic & commercial organic wastewater ($TOW_{d\&c}$ in kgBOD/yr) was calculated by formula:

$$TOW_{dom} = P \bullet D_{d\&c} \bullet (1 - DS_{d\&c})$$

Where

P population in 1000 persons;

$D_{d\&c}$ domestic & commercial DC in kgBOD/1000 persons/yr;

$DS_{d\&c}$ fraction of domestic & commercial DC removed as sludge.

In the previous inventories, wastewater and sludge handling emissions were estimated based only on the urban population of the country, as wastes produced in rural areas decompose in an aerobic environment. According to the 2006 IPCC, it is good practice to treat the three categories of residents: rural population, urban high income population, and urban low income population. Data on urban population distribution by income is anavialble in Georgia.

Emission factors depend on the fraction of wastewater managed by each wastewater handling method, maximum CH_4 producing capacity of the wastewater, and the degree to which wastewater handling process is anaerobic.

To calculate emissions factors for each wastewater and sludge type, a weighted average of methane conversion factors (MCF) is calculated using estimates of wastewater managed by each wastewater handling method. The average MCF is then multiplied by the maximum methane producing capacity (Bo) of the wastewater type.

The emission factor is calculation as

$$EF_i = Bo_i \bullet \sum (WS_{ix} \bullet MCF_x),$$

where

EF_i emission factor ($kgCH_4$/kgDC) for wastewater type i

Bo_i maximum methane producing capacity ($kgCH_4$/kgDC) for wastewater type i

WS_{ix} fraction of wastewater type i treated using wastewater handling system x

MCF_x methane conversion factors of each wastewater system x

Bo is the maximum amount of CH_4 that can be produced from a given quantity of wastewater or sludge. Bo is expressed in units of $kgCH_4/kgDC$, where DC is either COD or BOD. For typical domestic raw sewage, COD is 2-2.5 times higher than BOD. It is good practice to use a default value of 0.25 $kgCH_4/kgCOD$, or a default value of 0.6 $kgCH_4/kgBOD$. The default for sludge removal is zero (2006 IPCC, p.6.9). The MCF defines the portion of CH_4 producing potential (Bo) that is achieved. The MCF varies between 0.0 for a completely aerobic system, to 1.0 for a completely anaerobic system.

Emission Factors: Recommended by the 1996 IPCC and IPCC GPG default values: Bo=0.6 $kgCH_4/kgBOD$ and $D_{d\&c}$ = 0.05 kgBOD/cap/day (18,250 kgBOD/1000 persons/yr) are used. According to the IPCC 1996 methane conversion factor - MCF varies within 70-80%. Calculations were carried out applying the parameter MCF=75%, i.e. 75 percent of Domestic & Commercial wastewater was treated in anaerobic systems. In Georgian villages latrines small family (3-5 persons) are commonly used, for rural areas MCF=10%. The WS varies within 0.1-0.8. WS=0.45 for urban and WS=1 for rural areas.

Activity data: Data on urban and rural population whose wastewater is handled were provided by the National Statistic Office of Georgia.

TABLE 8.9 URBAN AND RURAL POPULATION IN 2010-2013

Population / Year	2010	2011	2012	2013
Urban	2,351	2,371	2,392	2,411
Rural	2,086	2,098	2,106	2,073
Total, thousand habitants	4,436	4,469	4,498	4,484

GHG Emissions: CH_4 emissions for domestic and commercial wastewater handling are shown in Table 8.10.

TABLE 8.10: CH4 EMISSIONS FROM DOMESTIC & COMMERCIAL WASTEWATER HANDLING IN 2010-2013

Source	2010	2011	2012	2013
CH_4 from urban population	8.7	8.8	8.8	8.9
CH_4 from rural population	2.3	2.3	2.3	2.3
Emission in $GgCH_4$	11.0	11.1	11.1	11.2
Emission in $GgCO_2eq$	230	232	234	235

8.3.2.NITROUS OXIDE FROM HUMAN SEWAGE

Consumption of foodstuffs by humans results in the production of sewage, which is disposed off directly on land, or discharged into a water source (e.g., rivers and estuaries). Before disposal on land or into water, it also can be processed in septic systems or wastewater treatment facilities. During all of these stages, nitrous oxide may be produced as a result of nitrification and denitrification of sewage nitrogen.

The main source of nitrogen from human sewage is protein (from the Greek protas meaning "of primary importance"). Protein is a complex, high-molecular-mass, organic compound consisting of amino acids joined by peptide bonds. Proteins are essential to the structure and function of all living cells and viruses. Every type of tissue in the body, including bones, skin, muscles, and organs, has its own set of proteins helping it perform its characteristic functions. Proteins give structure to our cells and are important in cell growth, repair, and maintenance. Like carbohydrates and fats, they can also serve as an energy source. While animal meats are rich sources of this vital dietary element, protein is also found in plant foods, such as grains and legumes, and in eggs and dairy products, such as milk and yogurt.

According to the recently updated Dietary Reference Intake guidelines, the recommended daily consumption of protein for adult men, aged 19-70 is 56g of protein, and women aged 19-70 is 46g of protein per day. The difference is due to the fact that, in general, men's bodies have more muscle mass than women. Other recommendations suggest 1g of protein per kilogram of bodyweight, while some extreme sources suggest that higher intakes of 1-2 grams of protein per pound of bodyweight are desirable. Higher levels of protein intake have not been proven to be necessary and may be harmful due to an increased stress on the kidneys and liver.

Sewage nitrogen production can be estimated from the FAO's per capita protein consumption data and human population counts. The FAO Statistics Division provides per person protein consumption data for Georgia for 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 2008-2013 was estimated considering that by 2013 it had risen annually by 1 g/person/day.

Emissions of N_2O from human sewage are calculated by the formula:

$$N_2O(S) = \text{Protein} \bullet \text{FracNPR} \bullet NR_{PEOPLE} \times EF_6$$

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 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 8.11: N_2O EMISSIONS (IN GG) FROM HUMANE SEWAGE IN 2010-2013 YEARS

Source	2010	2011	2012	2013
Population	4,436	4,469	4,498	4,484
Protein consumption, g/person/day	80	81	82	83
N_2O emission in Gg	0.33	0.33	0.34	0.34
In CO_2eq	102	102	105	105

8.3.3. INDUSTRIAL WASTEWATER

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 propensity of the industry to treat their wastewater in anaerobic lagoons.

Methodology: The method to calculate emissions from industrial wastewater is similar to the method used for domestic wastewater. The development of emission factors and activity data is more complex, due to more varying types of wastewater, and several 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 is absent in Georgia.

For industrial wastewater streams, COD is the appropriate DC indicator. The 1996 IPCC provides default COD values for different industries by region. The default values of the wastewater produced per unit product by industry in m^3/tonne of product are provided in the IPCC GPG as well.

$$WM = \sum_i (TOW_i \bullet EF_i - MR_i)$$

Where

WM total methane emissions from industrial wastewater in $kgCH_4$;

TOW_i total organic waste for wastewater type i in kg BOD/yr;

EF_i emission factor for wastewater type i in $kgCH_4$/kgBOD;

MR_i total amount of methane recovered or flared from wastewater type i in $kgCH_4$.

Emission factor

$$EFj = Bo \bullet MCFj$$

Where:

EFj emission factor for each treatment/discharge pathway or system, kg CH4/kg COD,

J each treatment/discharge pathway or system

Bo maximum CH4 producing capacity, kg CH4/kg COD

MCFj methane correction factor (fraction) (See Table 6.8.)

If no country-specific data is available, it is good practice to use the IPCC COD-default factor for Bo (0.25 kg CH4/kg COD). For W and $D_{Ind,}$ the default values from the IPCC GPG are used.

The total organic wastewater (TOW_{Ind}) for particular industry is calculated by the formula:

$$TOW_{Ind} \text{ (kg COD/yr)} = W \bullet O \bullet D_{Ind} \bullet (1 - DS_{Ind}),$$

Where:

W wastewater produced in m^3/tonne of product

O total output by selected industry in tonnes/yr

D_{Ind} industrial degradable organic component in kgCOD/m^3 wastewater

DS_{Ind} fraction of industrial degradable organic component removed as sludge

TABLE 8.12: WASTEWATER PRODUCTION AND DEGRADABLE ORGANIC COMPONENT FOR DIFFERENT INDUSTRIES

Industry type	Wastewater Produced (m^3/tonne product)	Degradable Organic Component (kg COD/m^3 wastewater)
Iron and Steel	17	1
Non-ferrous Metals	20	1
Fertilizer	10	1
Beer	6.3	2.9
Wine	23	1.5
Meatpacking	13	4.1
Dairy Products	7	2.7
Fish Processing	13	2.5
Oil & Grease	3.1	0.85
Soft Drinks	2	2
Paper	162	9
Alcohol Refining	24	2.9
Soap & Detergents	3	0.85
Vegetables, Fruits & Juices	20	1.5

Activity data: Production data for different industries provided by the National Statistic Office of Georgia are given in Table 8.13.

TABLE 8.13: DIFFERENT INDUSTRIES PRODUCTION DATA IN THOUSAND TONNES

Industry	2010	2011	2012	2013	2014
Iron and Steel	NA	NA	NA	NA	NA
Non-ferrous Metals	203,791	242,746	261,075	253,361	243,951
Canneries	616	1,084	1,273	766	1,320
Beer	82,790	78,739	99,034	100,900	119,003
Wine	25,898	30,435	46,228	67,160	110,499
MeatPacking	9,987	15,353	20,537	26,492	27,773
Dairy Products	24,745	33,549	40,432	46,441	53,994
Fish Processing	1,002	2,135	1,373	1,064	1,705
Oil & grease	3,218	11,883	5,368	6,758	1,294
Soft Drinks	154,052	137,426	191,968	189,551	222,698
Paper & Pulp	16,585	20,151	27,785	21,650	22,479
Alcohol Refining	22,594	23,483	33,682	39,282	27,662
Soap & Detergents	673	5,828	2,883	2,905	1,792
Vegetables, Fruits & Juices	3,507	8,943	7,905	6,595	12,492

TABLE 8.14: CH4 EMISSIONS FROM INDUSTRIAL WASTEWATER HANDLING FOR 2010-2013

Source	2010	2011	2012	2013
Emission in $GgCH_4$	1.36	1.63	2.18	2.09
Emission in $GgCO_2eq$	34	34	46	44

ANNEX A: 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 information is not intended to dispute the validity of the inventory estimates, but to help prioritize efforts to improve the accuracy of inventories and guide decisions on the methodological choice. Performance of this analysis, using correct analytical methods as minimum, is possible 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 quite detailed; it requires considerable resources and time.

For uncertainty assessment of the Georgian inventory, the relatively simple approach of Tier 1 was used, which is based on the following formulae:

Combined uncertainty using error propagation equation:

$$\mathbf{G}_{x} = \sqrt{\mathbf{E_x^2} + \mathbf{F_x^2}}$$

Combined uncertainty as a percentage of the total emissions in year 2013:

$$\mathbf{H_x} = \frac{\mathbf{G_x} * \mathbf{D_x}}{\sum \mathbf{D_i}}$$

Total emissions uncertainty using error propagation equation:

$$\boldsymbol{H_{tot}} = \sqrt{\sum_{x} \boldsymbol{H_x^2}}$$

Where,

$\boldsymbol{x}$ is an index that indicates the source-category,

$\mathbf{G}_{x}$ is combined uncertainty of x source-category,

$\mathbf{E_x}$ is activity data uncertainty of x source-category,

$\mathbf{F_x}$ is uncertainty of gas emission factor from x source-category,

$\mathbf{H_x}$ is percentage of combined uncertainty of 2013 in total emissions

$\mathbf{D_x}$ is emissions of 2013 from x source-category,

$\mathbf{H_{tot}}$ is total uncertainty of emissions

In addition, the formula below **(I_x)** was used to estmate 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 (2010) and the year t (2013) 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 (2010) and year t (2013) in response to a 1% increase in the emissions of source category x in 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.

To estimate the uncertainty in national emissions due to an uncertainty of emission factors (column Kthe following approach, advised by the IPCC methodology, was used:

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

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

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

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

To estimate uncertainty in national emissions due 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, is:

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

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

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

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

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

$$L_x = I_x * E_x$$

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 must be assessed on levels of each emission subcategory and activity data, and for each emission factors. 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. Their purpose is to identify categories (during the uncertainty assessment, as well as analysis of key categories) which require special attention 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 2013 was taken for the uncertainty assessment, and 2010 as 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 is given in Table 9.1 and calculations of the uncertainty are presented in Table 9.2. The results revealed that the level of emissions' uncertainty is within 25.14% (excluding LULUCF sector - 9.89%), and the uncertainty trend - 43.71% (excluding LULUCF sector - 13.13%). The highest uncertainty assessments have fugitive emissions from coal, oil and gas extraction and indirect emissions from agriculture, as well as methane and nitrous oxide emissions from biomass combustion. Uncertainty is also fairly high in case of nitrous oxide emissions from Commercial and Public Services, Residential, Agriculture, Fishing and Forestry.

The Energy Sector

Fuel combustion (1.A)

Uncertainty estimates are an essential element of a complete emission inventory. Uncertainty information is not intended to dispute the validity of the inventory estimates, but to help prioritize 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 small. Experts believe that uncertainty resulting from the two errors is probably in 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 some countries

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 these properties. Consequently, the errors could be considered, mainly, 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[64].

The IPCC typical value of uncertainty for countries with less well-developed energy data systems, where no good practice of energy balances creation exists - is 10%; in case of countries with well-developed energy data systems the uncertainty is 5%. A complete official energy balance was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for the 2013 reference period), but the energy balance for 2010 is not an official report. Therefore, the uncertainty is 8%.

The data on consumption of firewood has high uncertainty. The data is based on survey results on consumption of energy forms, which was conducted by the National Statistics Office of Georgia (GEOSTAT), as well as data from Georgia's Energy Balance, which was compiled by GEOSTAT in 2014 (for the reference period of 2013). Compared to the 2013 inventory report, more reliable data on consumption of fire wood is available, which has been collected by GEOSTAT since 2014 through household surveyss and surveys in other sectors (industry, construction etc). As mentioned above, the standard IPCC value of uncertainty for countries with less well-developed energy data systems, where energy balances creation are not well practised, is 10%; in case of countries with a well-developed energy data systems, theuncertainty is 5%. Due to the fact that fire wood is mainly consumed by the household sector, survey respondents may asses and indicate inaccurate (approximately) volumes of

[64] http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf (pg. 2.15)

consumed firewood, especially when consumed firewood is not purchased. That's why the 25% uncertainty value was selected.

As for emission factors, for all type of fuels the standard IPCC values (5%) were selected.

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 Annex A.

As a result of the analysis, the highest uncertainty (103.08%) is burning of firewood in case of methane and nitrous oxide besides burning of firewood, diesel and petrol combustion in road transport and gas consumption in various sectors have also a high contribution in the uncertainty of the burning of fuel category.

Fugitive emissions (1B)

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

Following calculations, the uncertainty of this category were assessed at 50.74%. It is also notable that methane emissions from gas transmission and distribution is the category with the highest contribution in total uncertainty, among all categories covered in the National Inventories; respectively, it requires special attention.

Industrial Processes

Cement Production (2A1)

The uncertainty estimation of CO_2 emissions from cement production is based on th uncertainty assessment for emission factors and activity data.

The activity data is sufficiently accurate, their uncertainty is about 5%. As for the emission factor, its uncertainty depends on the standard permissible content of CaO (error in assuming an average CaO in clinker of 65% (CaO usually 60-67%). IPCC 1996), because the multiplier 0.785 (molecular weight ratio of CO_2 / CaO = 44.01 / 56.08) is constant. According to the IPCC 1996 Guidelines[65], it is assumed that the content of CaO is standard, associated with 4-8% of uncertainty. Other causes of uncertainty[66] have no place, so the uncertainty of emission coefficients is about 5%.

Consequently, the combined uncertainty is 7.07%. This number is consistent with the assessment given in the Guidelines (IPCC 1996), according to which emission uncertainty is within 10 % if there is a direct data about clinker amount, as it was in case of Georgia, and it is not calculated from its derivatives, the cement amount.

Time series are consistent, as the calculation of emissions was done annually with the same methodological approach and emission factors.

Lime Production (2A2)

[65] http://www.ipcc-nggip.iges.or.jp/public/gp/english/3_Industry.pdf (Table 3.2)

[66] http://www.ipcc-nggip.iges.or.jp/public/gl/invs6b.html. (Table 2.3, pg 2.17)

Uncertainty estimation of emission is based on the coefficients of emission and the uncertainty estimation of activity data.

The stoichiometric ratio is an exact number 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 other types). Therefore, the total uncertainty is 15% at most (see Table 3.4, Basic Parameters for the Calculation of Emission Factors for Lime Production).

The uncertainty for the activity data is likely to be much higher than for the emission factors.

The data was taken from the National Statistics Office of Georgia (GEOSTAT), however, as far as lime production is scattered in many small enterprises, there is no basis for the full credibility that this data is complete. According the IPCC methodology, this uncertainty could be quite big. In the case of Georgia, based on experts' assessment, the uncertainty of activity data from this source is estimated as not less than 50%.

Consequently, the combined uncertainty (boundaries of emission assessment) is ±52.2% derived from the error propagation equation.

The time series are consistent, as the calculation of emissions for every year, and calculations for previous years, were performed with the same methodological approach and emission factors.

Limestone and Dolomite Use (2A3)

Uncertainty estimation of emission is based on coefficients of emission and uncertainty estimation of activity data.

Activity data uncertainties are greater than the uncertainties associated with emission factors. Assuming that carbonate consumption is allocated to the appropriate consuming sectors/industries, the uncertainty associated with weighing or proportioning the carbonates for any given industry is 1-3 percent. The uncertainty of the overall chemical analysis pertaining to carbonate content and identity also is 1-3 percent. The uncertainty associated with using the Tier 2 and Tier 1 methods, including the assumption of a default breakdown of limestone versus dolomite of 85%/15%, varies depending on country specific circumstances.

Activity data for limestone and dolomite use may be difficult to collect, as there are a variety of end uses in different industries, some of which are emissive and others are not. National statistics may include an end use category of 'other unspecified uses' (or an otherwise similar category) and it may be difficult to allocate 'other unspecified uses' for the appropriate consuming sector. If all usescannot properly be identified, this will increase uncertainty[67].

Data is collected from internet recourses and from "Ksani Glass Container Factory". Therefore, there is no full confidence that the data is complete.

According to the 1996 IPCC guidelines, this uncertainty can be quite high. In Georgia's case, based on experts' assessment, uncertainty of activity data from this source is estimated as not less than 50%.

[67] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf (pg. 2.39)

As for the emission factors, as far as one parameter (stoichiometric ratio) is a constant number in the formula, its uncertainty is determined by the composition of lime and dolomite, it brings 15% uncertainty into the emission coefficients. Other components (other types of raw materials: fillers and color components) due to the small effect, from which comes 2% of uncertainty, the overall rate of emission uncertainty is about 15% (IPCC GPG).

Consequently, combined uncertainty (boundaries of emission assessment) is ±52.2% based on the error propagation equation.

The time series are consistent, as calculation of emissions for each year was performed with the same methodological approach and emission factors.

Asphalt Production (2A5)

Although results from the use of more sophisticated methods are considered as the most accurate, the uncertainty for NMVOC and CO emissions from road paving and asphalt roofing may be in the range of ±25 percent, and larger if the calculation was not based on detailed activity and control technology data (from −100 percent to +25 percent).

The emission factors for NMVOC and CO for batch mix and drum mix HMA production have an uncertainty range of about **±50** percent, while the default factors for total HMA production and for cutback asphalt production and use will be about ±100 percent uncertain (i.e., between -50 percent and +100 percent). When country-specific emission factors are used for cutback asphalt production and paving, the uncertainty in the emission factors may be considerably smaller, e.g. in the range of ±50 percent.

Production data for HMA and cutback asphalt may be as accurate as **±10** percent, when based on data compiled by the asphalt production or construction industry. However, when activity data on cutback asphalt needs to be extrapolated, the uncertainties are very large, since it has been observed for a number of countries that the amount of cutback asphalt used can vary substantially from year to year[68];

Road paving with Asphalt (2A6)

The uncertainty in production statistics of asphalt roofing material may be as accurate as ±10 percent, if accounting is complete. If that is not the case, the uncertainty at the high end of the range could be as high as 100 percent or more.

The data was taken from the Road Department of Georgia. However, because road paving with asphalt is carried out by many small companies, there is no basis for a complete confidence that the data is accurate.

The default fossil carbon content fraction of NMVOC from asphalt production and use for road paving varies between 40 to 50 percent by mass and is about 80 percent for NMVOC from asphalt roofing (calculated from the NMVOC speciation provided in the EMEP/CORINAIR Emission Inventory Guidebook)[69].

As for the emission factor, which was taken from the Methodological Guidelines, it is known that the general uncertainty of emission coefficient is about 15%.

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[68] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf (pg. 5.16)
[69] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf (pg. 5.16)

Source-Category Ammonia Production (2B1)

According the IPCC methodology[70], where activity data is obtained from plants, uncertainty estimates can be obtained from producers. This activity data is likely to be highly accurate (i.e., with uncertainty as low as ±2 percent), including uncertainty estimates for fuel use, uncertainty estimates for ammonia production, and CO_2 recovered. Data obtained from national statistical agencies usually do not include uncertainty estimates. It is good practice to consult with national statistical agencies to obtain information on any sampling errors. Where national statistical agencies collect data from the population of ammonia production facilities, uncertainties in national statistics are not expected to differ from uncertainties established from plant-level consultations. Where uncertainty values are not available from other sources, a default value of ±5 percent can be used.

In Georgia's case, activity data was collected from the National Statistics Office of Georgia (GEOSTAT), as well as from the enterprise – Rustavi Chemical Fertilizers Plant, and is quite accurate. Emissions are calculated from used natural gas volume, as well as from the produced ammonia amount. Based on the expert judgment their uncertainty is within 5%[71].

Uncertainties for the default values[72] are estimates based on data from EFMA. In general, default emission factors for gaseous inputs and outputs have higher uncertainties than for solid or liquid inputs and outputs. The uncertainty of the standard emission coefficient determines an uncertainty of CO_2 amount emitted from ammonia production, which is due to distinctions of standard values of specific production parameters and national conditions. In addition, not taking into consideration specific parameters of the gas used is an uncertainty. The 1996 Guidelines do not provide a standard limits of the emission coefficient uncertainty indication. According to the new Guidelines (2006 edition), using the Tier 1 approach to determine CO_2 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 used, 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 CO_2 emission in the case of Georgia, set the coefficient at 7% or more.

Consequently, the combined uncertainty is 8.6% based on the error propagation equation.

Nitric Acid Production (2B2)

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

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

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

[70] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf (pg 3.17)
[71] http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch2wb1.pdf (page 2.13 and page 2.14)
[72] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf (Table 3.1)

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

Cast Iron and Steel Production (2C1)

The activity data was collected from the National Statistics Office of Georgia (GEOSTAT), as well as from appropriate enterprises. Therefore, the data is rather accurate and their uncertainty value is 5%.

The uncertainty of default EF is within 25%[73] according to "Concepts for Development of Iron and Steel Industry in Georgia".

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

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

Ferroalloys Production (2C2)

The activity data was collected from the National Statistics Office of Georgia (GEOSTAT), as well as from the Metallurgy research Institute of Georgia. Therefore, the data is rather accurate. Based on expert assessment, their uncertainty value is 5%.

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

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

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

Solvents and Other Products Use (CRF Sector 3)

The calculations were conducted according to the number of the country's population due to the lack of accuracy of the activity data. According to expert estmations, the uncertainty is within 25%.

Agriculture

Enteric Fermentation

The activity data was taken from the official statistical publication and is is reliable. However, 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 its meat. Therefore, the uncertainty of activity data is moderate and does not exceed of 20%.

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[73] "Concepts for Development of Iron and Steel Industry in Georgia", Prepared: by the Academy of Science. By the Institute of Metallurgy, by the Technical University of Georgia, by the Centre for Studying of Industrial Forces and Natural Resources, Tbilisi, 2011

In general, the emission coefficients uncertainty is at least 30%, when evaluating with Tier 1 since they were taken from the standard form, without taking into account the specific nature of the country. This uncertainty reaches to 40% in the case of Georgia. As for activity data (heads of cattle by species), they should be considered as reliable, since they were provided by the National Statistics Office of Georgia (GEOSTAT).

Due to the mentioned, and based on the error propagation equation, the methane emission uncertainty is about 44.72%, while being assessed through Tier 1.

Manure Management (4.B)

Methane Emissions from Manure Management (4.B.a)

Uncertainty of the data of activity related to number of the animals is assessed at 20%, since it is based on a statistical publication. According to the IPCC GPG, 50% is taken for methane emission-related uncertainty. Consequently, the combined uncertainty (boundaries of emissions assessment) is 53.85%.

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 exact 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 was defined at 111.8%.

Agricultural soils

Decay of the wastes of harvest

The activity data was taken from the National Statistics Office of Georgia (GEOSTAT), which is a competent source and is quite accurate. Therefore, 20% was selected as the indicator of uncertainty.

The uncertainty for the emission coefficient wastaken from the IPCC standard range and is equal to 100%. Consequently, the combined uncertainty for this source-category is 101.98%.

Emissions from pasture range and puddock

All data (except the number of cattle, which is the same for 4A) was taken according to the IPCC standard value (nitrogen emissions from animals for annual rate – for Asia and the Far East).

The uncertainty to estimate emissions in this subcategory is associated with indicators of the number of cattle types of which manure scattered on pastures. Uncertainty of activity data (number of cattle) is 30%, the uncertainty value of the emission factor is 100%. Consequently, the combined uncertainty for 4D2 subcategory is 104.4%.

Indirect emissions from soils

The uncertainty was estimated for the following subcategories: Nitrogen volatilization and redeposition and Nitrogen leaching, erosion and washing down. The uncertainty of activity data in both subcategories is quite high and related to the assumption of the percentage leached. In addition, the nitrogen content in fertilizers has uncertainty. Finally, the uncertainty of activity data was set at 100%[74]. Consequently, the combined uncertainty is 141.42%.

Field burning of agricultural residues

The activity data was provided by the National Statistics Office of Georgia (GEOSTAT) and accordingly, it is reliable, but there is no good data on the balance of residual stock mass shares and the burnt mass shares, therefore, the uncertainty of activity data is 50%. According to the IPCC GPG, the uncertainty value of emission factors is 20% (p. 4.90)[75]. Consequently, the combined uncertainty (boundaries of emissions assessment) is 53.85%, in case of methane, as well as nitrous oxide emissions.

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

Source category: Forest land

Emission and removal factors

The FAO (in press) 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%)[76].

It should be mentioned that the uncertainty of basic wood density of pine, spruce and birch trees (predominantly stems) is under 20% in Hakkila's studies (1968, 1979) in Finland. The variability between forest stands should be lower or at most the same as for trees. The overall uncertainty of country-specific basic wood density values should be about 30%[77].

Activity data

According the IPCC methodology, uncertainties vary between 1-15% in 16 European countries (Laitat et al. 2000). The uncertainty of remote sensing methods is ±10-15%. Sub-units will have greater uncertainty, unless the number of samples is increased. Similarly, equality in uniformly sampling an area one tenth of the national total, will have one tenth the number of sample points. As a result, the uncertainty will be larger by about the square root of 10, or roughly 3.16National data on forest lands is not available, international data sources and their use uncertainty are used as a result[78].

Cropland

The sources of uncertainty in this method are from the use of global or national average rates of conversion and coarse estimates of land areas converted to cropland. In addition, reliance on

[74] http://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf (pp.4.75)
[75] http://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf (pg. 4.90)
[76] https://www.ipcc.ch/meetings/session25/doc4a4b/vol4.pdf (pg. 4.18)
[77] http://www.ipcc.ch/meetings/session21/doc5to8/chapter32.pdf (gp. 3.22)
[78] http://www.ipcc.ch/meetings/session21/doc5to8/chapter32.pdf (pg. 3.23)

default parameters for carbon stocks in initial and final conditions contributes to relatively high degrees of uncertainty. The default values in this method have corresponding error ranges associated with them. A published compilation of research on carbon stocks in agro forestry systems was used to derive the default data provided in Section 3.3.2.1.1.2 (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 carbon stock was assumed based on expert judgment[79].

Grassland

Area data and estimates of uncertainty should be obtained using the methods in Chapter 3 (IPCC guideline). Tier 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, according to the IPCC guideline it is good practice for the inventory compiler to derive uncertainties from country-specific activity data, instead of using a default level. Therefore, in case of Georgia, activity data is quite accurate and based on expert assessment its uncertainty value is within 15%.

In terms of uncertainty of emission factors, according the IPCC methodology[80] and based on expert judgment, a default uncertainty value of 75% was selected.

Waste

Solid Waste Disposal

Uncertainty estimates for Total Municipal Solid Waste (MSW_T) and Fraction of MSW sent to SWDS (MSW_F) and the default model parameters are given in Table 5.2[81]. The estimates are based on expert judgement.

Some uncertainty information is available on the methane generation potential (L_0), which equals MCF • DOC • DOC_F • F • 16 / 12, and appears as a factor in the equations for both the default and the FOD methods. In countries, where high quality data is available, the uncertainty for CH_4 generation per tonne of waste is estimated to be approximately ±15% (Oonk and Boom, 1995). In countries with similar quality data, uncertainties in quantities of CH_4 generation per tonne of waste are expected to be of the same order. For countries with poor quality data on CH_4 generation per tonne of waste, the associated uncertainties could be of the order of ±50%.

Uncertainties of **Total Municipal Solid Waste (MSWT)** and **Fraction of MSW sent to SWDS (MSWF)** are caused by unreliable methods of collecting parameters such as: weight, refuse truck capacity, the number of population of whom waste is taken to a landfill. Each of them has its limits of uncertainty, which are provided by the IPCC[82]. In the case of Georgia, a waste generation rate and a share of waste carried out to landfills were taken from different sources, which are referred to in the previous chapters.

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79 http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Chp3_3_Cropland.pdf (pg. 3.73; 3.87 and 3.89)
80 http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Chp3_4_Grassland.pdf (pg. 3.109; 3.118)
81 http://www.ipcc-nggip.iges.or.jp/public/gp/english/5_Waste.pdf (pg. 5.12)
82 http://www.ipcc-nggip.iges.or.jp/public/gp/english/5_Waste.pdf (pp. 5.12)

According IPCC's methodology, the uncertainty range for the parameter Total Municipal Solid Waste (MSW_T) and Fraction of MSW sent to SWDS (MSW_F) can be estimate country-specific: >±10% (>-10%, >+10%. The absolute value of the uncertainty range is greater than 10% for countries with high quality data (e.g. weighing at all SWDS), but for countries with poor quality data: more than a factor of two.

Therefore, in this case the uncertainty was estimated at 20%, while in the previous inventory it was estimated at 30%. However, it could not be ruled out that the uncertainty is much higher, as local municipalities have no accurate and reliable information on the amount / share of landfill waste. At the same time, there is high uncertainty in the number of the population of Georgia's towns/cities, as they are quite seasonal.

Bearing this in mind, and based on expert judgment, the uncertainty value for the total amount of municipal solid waste (MSW_T) is 30%.

For **DOC** (Degradable Organic Carbon), **DOC_F** (Fraction of Degradable Organic Carbon Dissimilated), **MCF** (Methane Correction Factor) and **F** (Fraction of CH4 in Landfill Gas) parameters, uncertainty values from the 1996 IPCC and the 2006 IPCC considering specific conditions were used. Namely:

According to the IPCC methodology, the uncertainty range for **DOC** (**Degradable Organic Carbon (=0,21))** parameter is -50%, +20%. This parameter is calculated for different types of waste based on data from ongoing surveys in Georgia. Therefore, its uncertainty is assessed within ± 10%.

According to the IPCC methodology, the uncertainty range for **DOC_F (Fraction of Degradable Organic Carbon Dissimilated (=0,77))** parameter is between -30%, +0% range. This parameter, for different waste types, is calculated using national data on waste composition (percentage composition of wastes). The uncertainty of this parameter is estimated as equal to ± 15% as intermediate value, as standard value 20%, and specific value ± 10%, based on a study of representative groups for the country.

Different boundaries of uncertainty with different values were used for the **MCF (Methane Correction Factor)** parameter (according to the management level and the depth of the landfill): *MCF*=1 (-10%, +0%); *MCF*=0.4 (±30%); *MCF*=0.6 (-50%, +60%).

According to the IPCC methodology, the uncertainty range for **F (Fraction of CH_4 in Landfill Gas (= 0.5))** parameter is between a -0%, +20% range. For this parameter, the standard value of 0.5 was used, which is recommended by the 1996 IPCC[83] . Consequently, the uncertainty limits are taken for the standard value and are equal to ± 5%.[84].

According to the IPCC methodology, the uncertainty range for **Methane Generation Rate Constant (k) = 0.05** parameter is between -40%, +300% range.

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

Industrial Waste Water handling

[83] http://www.ipcc-nggip.iges.or.jp/public/gl/pdfiles/rusch6-1.pdf (pp. 6.3)

[84] http://www.ipcc-nggip.iges.or.jp/public/2006gl/russian/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf (pp. 3.33)

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[85]:

- 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%;
- For Maximum Methane Producing Capacity (Bo) - 30%.

The combined uncertainty of this source-category, based on uncertainties of emission factors and activity data, equals to 80.77%.

Domestic Waste Water handling

The data of domestic and commercial waste water (Domestic Waste Water handling) includes the number of population and the share of anaerobic treated wastewater. The uncertainty of standard limits of all values are based on experts' judgments and the IPCC methodology[86]:

- Uncertainty for the number of population is within 5% limit.
- For BOD biological oxygen demand (BOD/person) - 30%;
- For Maximum Methane Producing Capacity (Bo) - within 30%;
- For Fraction Treated Anaerobically - 10%.

According to these, the limits of emission uncertainty estimation, based on the equation of uncertainty (error propagation equation), is approximately 43.6% and the total value of uncertainty of this source-category is 43.89%.

The sewage waters include human and industrial wastewater. This emission is calculated separately from domestic wastewater.

The only national value for the emission calculation formula is the number of population, of 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 at approximately 70%.

These ranges of activity data and emission uncertainty factor are used to calculatethe total uncertainty in methane and nitrous oxide emissions, which makes 80.77% for industrial wastewater, 42.43% for domestic and commercial wastewater -, and 70.18% nitrous oxide emissions.

[85] http://www.ipcc-nggip.iges.or.jp/public/gp/english/5_Waste.pdf (Table 5.5, pp. 5.23)
[86] http://www.ipcc-nggip.iges.or.jp/public/gp/english/5_Waste.pdf (Table 5.3, pg. 5.19)

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
1A1	Liquid fuels for Electricity and Heat Production	**CO_2**	The IPCC typical value is 10% of uncertainty for countries with less well-developed energy data systems, where there is not a good practice of energy balances creation; in case of countries with well-developed energy data systems the uncertainty is 5%. The complete official energy balance was developed by the National Statistics office of Georgia (GEOSTAT) in 2014 (for 2013), but the energy balance for 2010 is not the official version. Therefore, uncertainty was given at 8%.	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	Gas for Electricity and Heat Production	**CO_2**	The IPCC typical value is 10% of uncertainty for countries with less well-developed energy data systems, where there is not a good practice of energy balances creation; in case of countries with well-developed energy data systems the uncertainty is 5%. The complete official energy balance was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for 2013), but the energy balance for 2010 is not the official version. Gas consumption in this sector is relatively well-recorded in Georgia. Therefore, the uncertainty was set at5%.	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 fuel	**CO_2**	The IPCC typical value is 10% of uncertainty for countries with less well-developed energy data systems, where there is not a good practice of energy balances creation; in case of countries with well-developed energy data systems the uncertainty is 5%. The complete official energy balance was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for 2013), but the energy balance for 2010 is not the official version (data about mining was available before 2013, but data about consumption and stock changes is only available since 2013), therefore uncertainty was set at 8%.	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.

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
1A2	Manufacturing Industries and Construction - liquid fuel	CO_2	Typical 8%.	Typical 5%.
1A2	Manufacturing Industries and Construction - Gas	CO_2	Typical 8%.	Typical 5%.
1A3 a	Civil aviation	CO_2	Typical 8% (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.63).	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.
1A3 b	Road transport - Diesel	CO_2	Typical 8%.	Typical 5%. (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.49)
1A3 b	Road transport - Gasoline	CO_2	Typical 8%.	Typical 5%.
1A3 b	Road transport - Gas	CO_2	Typical 8%.	Typical 5%.
1A3 c	Other Transportation	CO_2	Typical 8%.	Typical 5%.
1A4 a	Commercial and Public Services - Solid Fuel	CO_2	Typical 8%.	According to the IPCC Guidelines, selection of typical value for emission factors is within 95% confidence interval and uncertainty has less than 5%. Since, there doesn't exist exact data on coal mining and its emission factors in Georgia, higher value was chosen - 8%.
1A4 a	Commercial and Public Services - Liquid Fuels	CO_2	Typical 8%.	Typical 5%.

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
1A4 a	Commercial and Public Services - Gas	CO_2	Typical 8%.	Typical 5%.
1A4 b	Residential - Solid Fuel	CO_2	Typical 8%.	Typical 5%.
1A4 b	Residential - Liquid Fuels	CO_2	Typical 8%.	Typical 5%.
1A4 b	Residential - Gas	CO_2	Typical 8%.	Typical 5%.
1A4 c	Agriculture, Fishing and Forestry - Solid Fuel	CO_2	Typical 8%.	Typical 5%.
1A4 c	Agriculture, Fishing and Forestry - Liquid fuels	CO_2	Typical 8%.	Typical 5%.
1A4 c	Agriculture, Fishing and Forestry - Gas	CO_2	Typical 8%.	Typical 5%.
1A5	Other (not elsewhere specified)	CO_2	Typical 8%.	Typical 5%.
2A1	Cement Production	CO_2	Activity data is quite accurate; therefore, its uncertainty value is within 5%.	Activity data is quite accurate and its uncertainty value is within 5%. As for the emission coefficient, its uncertainty depends on the CaO standard composition (Error in assuming an average CaO in clinker of 65% (CaO usually 60-67%) assumptionsince the factor of 0,785 (molecular weight ratio of CO2/CaO=44,01/56,08) is constant. According to the IPCC 1996 Guidelines instructions (Table 3.2), with the assumption that the content of CaO is standard, it is associated with 4-8% uncertainty. Other causes of uncertainty (see the same Table) do not occur.Therefore, the emission coefficients uncertainty is within 5%.

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
2A2	Lime Production	**CO_2**	The source of the data on lime production is the National Statistics Office of Georgia (GEOSTAT), however, as far as lime production is scattered in many small enterprises, it is unknown if the data is complete. According to theIPCC methodology, this uncertainty could be quite big. In Georgia's case, based on the experts' assessment, the uncertainty of activity data from this source is estimated as not less than 50%.	The stoichiometric ratio is an exact number and, therefore, the uncertainty of the emission factor is the uncertainty of lime composition, in particular the share of hydraulic lime that has 15% uncertainty in the emission factor (2% uncertainty in the other types). Therefore, the total uncertainty is 15% at most (see Table 3.4, Basic Parameters for the Calculation of Emission Factors for Lime Production).
2A3	Limestone and Dolomite Use	**CO_2**	Data was collected from internet recourses and from the Ksani Glass Container Factory. Therefore, the data may be incomplete. According to the 1996 IPCC guidelines, this uncertainty can be quite high. In Georgia's case, based on the experts' assessment, the uncertainty of activity data from this source is estimated as not less than 50%.	As one parameter (stoichiometric ratio) is the constant number in formula, its uncertainty is determined from the lime and dolomite composition, which takes 15% of uncertainty in the emission coefficients. Due to the small effect of other components (other kinds of raw materials: fillers and coloring components), the share of which is 2% of uncertainty, the overall uncertainty of the emission coefficients is approximately 15% (IPCC GPG).
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 israther accurate data. Emissions are calculated from the used natural gas volume, as well as from the produced ammonia amount. Based on the expert judgment, their uncertainty is within 5% http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf (pg 3.17).	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 expert assessment, the overall uncertainty of the CO_2 emmission coefficient is not less than 7%. http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf (Table 3.1)
2C1	Cast Iron and Steel Production	**CO_2**	Activity datawas collected from the National Statistics Office of Georgia (GEOSTAT), as well as from appropriate enterprises. Therefore, the data is relatively	The uncertainty of the emission standard coefficients is within 25%.

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
			accurate, and their uncertainty value is 5%.	
2C2	Ferroalloys Production	CO_2	Activity data was collected from the National Statistics Office of Georgia (GEOSTAT), as well as from the Metallurgy research Institute of Georgia. Therefore, the data is relatively 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 in a 25% range.
5A	Forest Land	CO_2	According to the IPCC methodology, uncertainties vary between 1-15% in 16 European countries (Laitat et al. 2000). The uncertainty of remote sensing methods is ±10-15%. Sub-units will have greater uncertainty unless the number of samples is increased. Similarly, equality in uniformly sampling an area one tenth of the national total, will have one tenth the number of sample points. Hence the uncertainty will be larger by about the square root of 10, or roughly 3.16. In case the national data on areas of forest lands are not available, the inventory prepares should refer to international data sources and use uncertainty provided by them. In Georgia's case 15% uncertainty was selected.	It should be mentioned that the uncertainty of basic wood density of pine, spruce and birch trees (predominantly stems) is under 20% in Hakkila's studies (1968, 1979) in Finland. The variability between forest stands should be lower, or at most the same, as for trees. It is concluded that the overall uncertainty of country-specific basic wood density values should be about 30%
5B	Cropland	CO_2	Activity data is quite accurate. Based on expert assessment, its uncertainty value is within 15%.	The sources of uncertainty in this method are from the use of global or national average rates of conversion and coarse estimates of land areas converted to cropland. In addition, reliance on default parameters for carbon stocks in initial and final conditions, contributes to relatively high degrees of uncertainty. The default values in this method have correspo-nding error ranges associated with them. The defaults were derived from multiple studies and an uncertainty level of +/- 75% of the carbon stock was assumed based on expert

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
				judgment
5C	Grassland	**CO_2**	Activity data is quite accurate. Based on expert assessment, its uncertainty value is within 15%.	According to the IPCC methodology and based on expert judgment, the default uncertainty value of 75% was selected.
1A1	Stationary Fuel Combustion (except biomass)	**CH_4**	Typical 8%.	According to the IPCC GPG document, Table 2.5 reads that the uncertainty boundary is in the 50%-150% interval. In Georgia's case the intermediate at 100% was selected. (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg 2.41)
1A2	Fuel Combustion (biomass)	**CH_4**	The data was derived from survey results on consumption of energy forms, which was conducted by the National Statistics Office of Georgia (GEOSTAT), as well as data from the Energy Balance of Georgia, which was compiled by GEOSTAT in 2014 (for the reference period of 2013). Compared to the previous inventory report, more reliable data on consumption of fire wood is available from 2013, which is collecting by GEOSTAT since 2014, as a results of the household survey, as well as a survey on other sectors (industry, construction etc). As mentioned previously, the IPCC typical value is 10% of uncertainty for countries with less well-developed energy data systems, where there is not a good practice of energy balances creation; in case of	According to the IPCC GPG document, Table 2.5, the uncertainty boundary is in the interval of 50%-150%. In Georgia's case the intermediate 100% was selected. (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg 2.41)

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
			countries with well-developed energy data systems the uncertainty is 5%. Due to the fact that fire wood is mainly consumed by the household sector, survey respondents may asses and indicate an inaccurate (approximately) volume of consumed firewood, especially when the consumed firewood is not purchased. That's why an uncertainty value of 25% was selected.	
1A3 a	Civil Aviation	**CH_4**	Typical 8% (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.63)	Typical 10% (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.63)
1A3 b	Road Transport	**CH_4**	Typical 8%.	Typical 40% (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.49). 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. The major source of uncertainty is emission factors as well.
1A3 c	Other Transportation	**CH_4**	Typical 8%.	Typical 100%.
1A4 a	Commercial and Public Services	**CH_4**	According to the IPCC GPG document, Table 2.6 (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.41), an uncertainty value of 8% was selected, as energy statistics system in Georgia were developed from 2014, when appropriate, whenstatistical surveys were	According to the IPCC GPG document, Table 2.5, the uncertainty boundary is in the 50%-150% interval. In Georgia's case the iIntermediate 100% was selected. (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg 2.41)

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
			conducted for 2013.	
1A4 b	Residential	**CH_4**	According to the IPCC GPG document, Table 2.6 (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.41), an uncertainty value of 8% was selected, as energy statistics system in Georgia were developed from 2014, when appropriate statistical surveys wereconducted for 2013.	According to the IPCC GPG document, Table 2.5, the uncertainty boundary is in the 50%-150% interval. In our case the intermediate 100% was selected. (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg 2.41)
1A4 c	Agriculture, Fishing and Forestry	**CH_4**	The IPCC GPG document does not provide uncertainty typical values for Agriculture, Fishing and Forestry sectors (see. Table 2.6, http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.41), that is why uncertainty typical values for other sectors (Commercial and Public Services, Residential) were used - 8%.	The IPCC GPG document does not provide uncertainty typical values for Agriculture, Fishing and Forestry sectors (see. Table 2.5 http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.41), that is why the uncertainty typical values for other sectors (Commercial and Public Services, Residential) were used - 100%.
1B1	Fugitive Emissions from Solid Fuel Mining and Transformation	**CH_4**	Coal mining data provided by GEOSTAT is reliable and, therefore, the uncertainty value of 5% was chosen. http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.77	According the IPPC methodology, using the typical emission factor for this category has a vast uncertainty value. Therefore, an uncertainty value of 300% was chosen. http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.76

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
1B2	Fugitive Emissions from oil Extraction	**CH_4**	Data on Oil extraction is provided by the Oil and Gas Corporation and is reliable. Therefore, the uncertainty value of 5% was chosen	According the IPPC methodology, using the typical emission factor for this category has a vast 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. While some semi-quantitative analyses were conducted, a more thorough quantitative analysis is warranted. Therefore, an uncertainty value of 300% was chosen. (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.92)
1B2	Fugitive Emissions from Natural Gas Production	**CH_4**	Data on gas production was provided by the Oil and Gas Corporation and is reliable. Therefore, an uncertainty value of 5% was chosen	According the IPPC methodology, using the typical emission factor for this category has a vast 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. While some semi-quantitative analyses were conducted, a more thorough quantitative analysis is warranted. Therefore, an uncertainty value of 300% was chosen. (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.92)
1B2	Fugitive Emissions from Natural Gas Transmission and Distribution	**CH_4**	The data was calculated using the analytical method, it is not based on real measurements and, therefore, an uncertainty value of 50% was chosen.	The used method takes turning gas into methane into consideration and does not use the IPCC methodology. As a result, the main uncertainty is in the activity data. Therefore, a 10% value was chosen for emission factors.

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
4A	Enteric Fermentation	**CH_4**	The activity data was taken from the official statistical publication and is reliable. However, classification and distribution of cattle is not entirely consistent with the IPCC standard on dairy and non-dairy cattle. Nevertheless, there is reasonable assumption that the data provided by GEOSTAT about “cows” and “other cattle” conform with the classification of "dairy" and “non-dairy cattle”, as the cows were intended for exactly dairy purpose and the rest for its meat. As a result, it should be considered that the uncertainty of activity data is moderate and does not exceed 20%.	In general, the emission coefficients uncertainty is at least 30%, when evaluating with Tier 1, as they are taken from the standard form, without taking into account the specific nature of the country. This uncertainty reaches to 40% in the case of Georgia.
4B	Manure Management	**CH_4**	The uncertainty of activity data related to animal number is estimated at 20%, as it is based on a statistical publication.	According to the IPCC GPG, 50% is taken for methane emissions-related uncertainty.
4F	Field Burning of Agricultural Residues	**CH_4**	The activity data was provided by the National Statistics Office of Georgia (GEOSTAT) and, accordingly, is reliable. However, there is no good data on the balance of residual stock mass shares and the burnt mass shares. Therefore, for the uncertainty of activity data, 50% was chosen.	According to IPCC GPG, the uncertainty value of emission factors is 20% (p. 4.90).
6A	Solid Waste Disposal Sides	**CH_4**	Estimations were calculated based on the IPCC GPG, Table 5.2; and similar calculations performed in the SNC. The final uncertainty of the activity data was estimated at 31.5% (http://www.ipcc-nggip.iges.or.jp/public/gp/english/5_Waste.pdf), pg. 5.12.	Estimations were calculated based on the IPCC GPG, Table 5.2; and similar calculations performed in the SNC. The uncertainty of emission factors was set at 30%.
6B1	Industrial Waste Water Handling	**CH_4**	Estimations were calculated based on the IPCC GPG, Table 5.5; and similar calculations performed in the SNC. The final uncertainty of the activity data was set at 56%. (http://www.ipcc-nggip.iges.or.jp/public/gp/english/5_Waste.pdf, pg. 5.23.	Estimations were calculated based on the IPCC GPG, Table 5.5; and similar calculations performed in the SNC. The final uncertainty of the activity data was set at 58%.

	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	CH_4	Estimations were calculated based on the IPCC GPG, Table 5.3; and similar calculations performed in the SNC. The final uncertainty of the activity data was set at 5%. (http://www.ipcc-nggip.iges.or.jp/public/gp/english/5_Waste.pdf, pg. 5.19.	Estimations were calculated based on the IPCC GPG, Table 5.3; and similar calculations performed in the SNC. The final uncertainty of the activity data was set at 44%.
1A1	Stationary Fuel Combustion (except biomass)	N_2O	Typical 8%.	According to the IPCC GPG document, Table 2.5, the uncertainty boundary is in the 50%-150% interval. In Georgia's case the intermediate 100% was selected. (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg 2.41)
1A2	Fuel Combustion (biomass)	N_2O	The data was based on survey results of the consumption of energy forms, which was conducted by the National Statistics Office of Georgia (GEOSTAT), as well as data on the Energy Balance of Georgia, which was compiled by GEOSTAT in 2014 (for 2013) Compared to the previous inventory report, from 2013 onwards more reliable data on consumption of fire wood is available, which was collected by GEOSTAT since 2014, as a results of households survey, as well as a survey on other sectors (industry, construction etc). As mentioned previously, the IPCC typical value is 10% of uncertainty for countries with less well-developed energy data systems, where there is not a good practice of energy balances creation; in case of countries with well-developed energy data systems the uncertainty is 5%. Due to the fact that fire wood is mainly consumed by the household sector, survey respondents may asses and indicate inaccurate (approximately) the volume of consumed firewood, especially when the consumed firewood is not purchased. That is why an uncertainty value of 25% was selected.	According to the IPCC GPG document, Table 2.5 - uncertainty boundary is in the interval of 50%-150%. In our case Intermediate 100% was selected. (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg 2.41)

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
1A3 a	Civil Aviation	**N_2O**	Typical 8% (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.63)	Typical 100% (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.63)
1A3 b	Road Transport	**N_2O**	Typical 8%.	Typical 50% (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.49.) Nitrous oxide usually contributes approximately 3% to the CO2-equivalent emissions from the transportation sector. Expert 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.
1A3 c	Other transportation	**N_2O**	Typical 8%	Typical 100%
1A4 a	Commercial and Public Services	**N_2O**	According to the IPCC GPG document, Table 2.6 - (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.41) an uncertainty value of 8% was selected, as the energy statistics system in Georgia was developed from 2014 onward, when appropriate statistical surveys were conducted for 2013.	According to the IPCC GPG document, Table 2.5 - (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.41), uncertainty ranges from one-tenth of the mean value, to ten times the mean value should be applied. In this case, 150% an uncertainty value was selected.
1A4 b	Residential	**N_2O**	According to the IPCC GPG document, Table 2.6 - (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.41), an uncertainty value of 8% was selected, as the energy statistics system in Georgia was developed from 2014 onward, when appropriate statistical surveys were conducted for 2013.	According to the IPCC GPG document, Table 2.5 - (http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.41), uncertainty ranges from one-tenth of the mean value, to ten times the mean value should be applied. In this case, an uncertainty value of 150% was selected.

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
1A4 c	Agriculture, Fishing and Forestry	N_2O	The IPCC GPG document does not provide uncertainty typical values for Agriculture, Fishing and Forestry sectors (see. Table 2.6, http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.41), that is why an uncertainty typical values of - 8% for other sectors (Commercial and Public Services, Residential) was used,	The IPCC GPG document does not provide uncertainty typical values for Agriculture, Fishing and Forestry sectors (see. Table 2.5 http://www.ipcc-nggip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.41), therefore, an uncertainty typical value of 150% for other sectors (Commercial and Public Services, Residential) was used.
2B2	Nitric Acid Production	N_2O	The activity data is rather accurate. Based on the expert judgment its uncertainty value does notexceed 5%.	A new IPCC manual allows standard boundaries of 20% uncertainty assessment for medium-pressure technology plants
3	Solvents and Other Product Use	N_2O	Activity data was collected from the National Statistics Office of Georgia (GEOSTAT) and, therefore, 25% of uncertainty was chosen.	There is no exact data on this methodology. According to the experts' assessment, depends on activity data, and 1% uncertainty value was selected.
4B	Manure Management	N_2O	The uncertainty of activity data for nitrous oxide emissions calculation in the manure management sector was 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 was collected from National Statistics Office of Georgia (GEOSTAT), which is a competent source and quite accurate. Therefore, 20% was selected as the indicator of uncertainty.	The uncertainty for emission coefficients were taken from the standard range of the IPCC and are equal to 100%. Therefore, the combined uncertainty value for this source-category was defined at 101.98%
4D2	Pasture Range and Puddock	N_2O	The uncertainty for estimating emissions in this subcategory is associated with the indicators of the number of cattle types of which manure scattered on pastures. The uncertainty of activity data (number of cattle) is 30%.	The data was taken according to the IPCC standard value (nitrogen emissions from animals for annual rate – for Asia and the Far East). Therefore, the uncertainty value of the emission factor is 100%.

	IPCC source-category	Gas	Uncertainty values in activity data and its selection reasons	Uncertainty in emission factors and its selection reasons
4D3	Indirect Emissions	**N_2O**	The uncertainty of activity data in both subcategories is quite high and related to how much percent will be leached. In addition, nitrogen content in fertilizers has uncertainty. Therefore, theuncertainty of activity data was set at 100%.	According to the IPCC GPG (p.4.75), the uncertainty of emission factors is in the same range. A value of 100% was selected due to the absence of better information.
4F	Field Burning of aAgricultural Residues	**N_2O**	The activity data was provided for by the National Statistics Office of Georgia (GEOSTAT) and, accordingly, is reliable. However, there is no reliable data on the balance of residual stock mass shares and the burnt mass shares. Therefore, the uncertainty of activity data was set at 50%.	According to the IPCC GPG, the uncertainty value of emission factors is 20% (p. 4.90).
6B2	Domestic Waste Water Handling	**N_2O**	The only national value in the formula to calculate emissions, is the population number=, of which the uncertainty is estimated within 5% and, accordingly, for the uncertainty value of emission, 5% was chosen.	The assessment for this source is based on estimations of standard coefficient (2006 IPCC) and is about 70%.
2F	Consumption of Halocarbons and Sulfur Hexafluoride (Refrigeration and Air Conditioning Equipments)	HFC	The quantitative activity data is relatively accurate. Based on the expert judgment, its uncertainty value is within 5%	The uncertainty level for standard coefficients of emission is estimated at 25% in the case of using Tier 1.
2F	Consumption of Halocarbons and Sulfur Hexafluoride (Emissions from Appliances - electrical equipment)	SF6	The quantitative activity data is relatively accurate. Based on the expert judgment, its uncertainty value is within 5%	The Tier 1 estimates are set at an uncertainty of 100% or more, representing an estimate of actual emissions. Therefore, the value oof 100% was selected. (http://www.ipcc-nggip.iges.or.jp/public/gp/english/3_Industry.pdf (pg. 3.61))

Uncertainty Analysis

	A	B	C	D	E	F	G	H	I	J	K	L	M
	IPCC source-category	**Gas**	**Emissions of 2010**	**Emissions of 2013**	**Uncertainty of activity data**	**Uncertainty of emission factors**	**Combined uncertainty**	**Percentage of combined uncertainty of 2013 in total emissions**	**A type sensitivity**	**B type sensitivity**	**Uncertainty in national emissions due to uncertainty of emission factors**	**Uncertainty in national emissions due to uncertainty of activity data**	**Uncertainty trend in national emission**
			Input data	**Input data**	**Input data**	**Input data**	$\sqrt{E^2+F^2}$	$\frac{G*D}{\sum D}$	Note B	$\frac{D}{\sum C}$	**I * F Note C**	J * E * $\sqrt{2}$ Note D	$\sqrt{K^2+L^2}$
			Gg CO2-eq.	**Gg CO2-eq.**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
1A1	Liquid Fuels for Electricity and Heat Production	**CO_2**	168.7	0.0	8	5	9.43	0.00	-0.02	0.00	0.00	-0.20	0.20
1A1	Gas for Electricity and Heat Production	**CO_2**	372.1	950.3	5	5	7.07	0.52	0.05	0.10	0.71	0.23	0.75
1A2	Manufacturing Industries and Construction - Solid Fuel	**CO_2**	561.3	1322.2	8	5	9.43	0.96	0.06	0.14	0.99	0.47	1.09
1A2	Manufacturing Industries and Construction - Liquid Fuel	**CO_2**	19.8	212.3	8	5	9.43	0.15	0.02	0.02	0.16	0.16	0.22
1A2	Manufacturing Industries and Construction - Gas	**CO_2**	305.6	388.6	8	5	9.43	0.28	0.00	0.04	0.29	-0.03	0.29
1A3a	Civil Aviation	**CO_2**	0.00	2.24	8	5	9.43	0.00	0.00	0.00	0.00	0.00	0.00
1A3b	Road Transport - Diesel	**CO_2**	1062.7	1223.2	8	5	9.43	0.89	-0.02	0.13	0.91	-0.20	0.93
1A3b	Road Transport - Gasoline	**CO_2**	1281.6	1148.0	8	5	9.43	0.83	-0.06	0.12	0.86	-0.52	1.00

	A	B	C	D	E	F	G	H	I	J	K	L	M
	IPCC source-category	**Gas**	**Emissions of 2010**	**Emissions of 2013**	**Uncertainty of activity data**	**Uncertainty of emission factors**	**Combined uncertainty**	**Percentage of combined uncertainty of 2013 in total emissions**	**A type sensitivity**	**B type sensitivity**	**Uncertainty in national emissions due to uncertainty of emission factors**	**Uncertainty in national emissions due to uncertainty of activity data**	**Uncertainty trend in national emission**
1A3b	Road Transport - Gas	**CO_2**	14.4	490.4	8	5	9.43	0.36	0.05	0.05	0.37	0.40	0.54
1A3c	Other Transportation	**CO_2**	199.2	201.8	8	5	9.43	0.15	-0.01	0.02	0.15	-0.06	0.16
1A4a	Commercial and Public Services - Solid Fuel	**CO_2**	0.0	1.8	8	5	9.43	0.00	0.00	0.00	0.00	0.00	0.00
1A4a	Commercial and Public Services - Liquid Fuels	**CO_2**	0.0	2.8	8	5	9.43	0.00	0.00	0.00	0.00	0.00	0.00
1A4a	Commercial and Public Services - Gas	**CO_2**	206.2	249.0	8	5	9.43	0.18	0.00	0.03	0.19	-0.03	0.19
1A4b	Residential - Solid Fuel	**CO_2**	0.0	1.5	8	5	9.43	0.00	0.00	0.00	0.00	0.00	0.00
1A4b	Residential - Liquid Fuels	**CO_2**	272.7	40.5	8	5	9.43	0.03	-0.04	0.00	0.03	-0.28	0.28
1A4b	Residential - Gas	**CO_2**	775.0	999.2	8	5	9.43	0.72	-0.01	0.11	0.75	-0.06	0.75
1A4c	Agriculture, Fishing and Forestry - Solid Fuel	**CO_2**	110.8	0.0	8	5	9.43	0.00	-0.02	0.00	0.00	-0.13	0.13
1A4c	Agriculture, Fishing and Forestry - Liquid Fuels	**CO_2**	99.5	28.4	8	5	9.43	0.02	-0.01	0.00	0.02	-0.09	0.09
1A4c	Agriculture, Fishing and Forestry - Gas	**CO_2**	84.6	3.3	8	5	9.43	0.00	-0.01	0.00	0.00	-0.10	0.10
1A5	Other (not elsewhere specified)	**CO_2**	241	12	8	5	9.43	0.01	-0.03	0.00	0.01	-0.27	0.27
2A1	Cement Production	**CO_2**	254.60	599.95	5	5	7.07	0.33	0.03	0.06	0.45	0.13	0.47
2A2	Lime Production	**CO_2**	35.44	890.93	50	15	52.20	3.57	0.09	0.09	1.99	4.44	4.87
2A3	Limestone and	**CO_2**	0.44	2.62	50	15	52.20	0.01	0.00	0.00	0.01	0.01	0.01

	A	B	C	D	E	F	G	H	I	J	K	L	M
	IPCC source-category	**Gas**	**Emissions of 2010**	**Emissions of 2013**	**Uncertainty of activity data**	**Uncertainty of emission factors**	**Combined uncertainty**	**Percentage of combined uncertainty of 2013 in total emissions**	**A type sensitivity**	**B type sensitivity**	**Uncertainty in national emissions due to uncertainty of emission factors**	**Uncertainty in national emissions due to uncertainty of activity data**	**Uncertainty trend in national emission**
	Dolomite Use												
2B1	Ammonia Production	**CO_2**	214.28	250.68	5	7	8.60	0.17	0.00	0.03	0.26	-0.02	0.26
2C1	Cast Iron and Steel Production	**CO_2**	3.29	17.85	5	25	25.50	0.03	0.00	0.00	0.07	0.01	0.07
2C2	Ferroalloys Production	**CO_2**	346.44	430.71	5	25	25.50	0.84	0.00	0.05	1.61	-0.02	1.61
5A	Forest Land	**CO_2**	-5209.20	-5502.60	15	30	33.54	-14.18	0.18	-0.58	-24.63	2.63	24.77
5B	Cropland	**CO_2**	-1132.60	-1091.90	15	75	76.49	-6.42	0.05	-0.12	-12.22	0.73	12.24
5C	Grassland	**CO_2**	2533.70	2533.70	15	75	76.49	14.89	-0.10	0.27	28.35	-1.49	28.39
1A1	Stationary Fuel Combustion (except biomass)	**CH_4**	11.91	6.57	8	100	100.32	0.05	0.00	0.00	0.10	-0.01	0.10
1A2	Fuel Combustion (biomass)	**CH_4**	90.46	120.12	25	100	103.08	0.95	0.00	0.01	1.79	-0.01	1.79
1A3a	Civil Aviation	**CH_4**	0.00	0.00	8	10	12.81	0.00	0.00	0.00	0.00	0.00	0.00
1A3b	Road Transport	**CH_4**	9.66	18.06	8	40	40.79	0.06	0.00	0.00	0.11	0.00	0.11
1A3c	Other Transportation	**CH_4**	0.03	0.05	8	100	100.32	0.00	0.00	0.00	0.00	0.00	0.00
1A4a	Commercial and Public Services	**CH_4**	8.56	2.52	8	100	100.32	0.02	0.00	0.00	0.04	-0.01	0.04
1A4b	Residential	**CH_4**	84.57	120.33	8	100	100.32	0.93	0.00	0.01	1.80	0.00	1.80
1A4c	Agriculture, Fishing and Forestry	**CH_4**	7.35	0.06	8	100	100.32	0.00	0.00	0.00	0.00	-0.01	0.01

	A	B	C	D	E	F	G	H	I	J	K	L	M
	IPCC source-category	**Gas**	**Emissions of 2010**	**Emissions of 2013**	**Uncertainty of activity data**	**Uncertainty of emission factors**	**Combined uncertainty**	**Percentage of combined uncertainty of 2013 in total emissions**	**A type sensitivity**	**B type sensitivity**	**Uncertainty in national emissions due to uncertainty of emission factors**	**Uncertainty in national emissions due to uncertainty of activity data**	**Uncertainty trend in national emission**
1B1	Fugitive Emissions from Solid Fuel Mining and Transformation	**CH_4**	75.18	113.40	5	300	300.04	2.61	0.00	0.01	5.08	0.01	5.08
1B2	Fugitive Emissions from Oil Extraction	**CH_4**	0.12	0.11	5	300	300.04	0.00	0.00	0.00	0.01	0.00	0.01
1B2	Fugitive Emissions from Natural Gas Production	**CH_4**	2.2	1.5	5	300	300.04	0.03	0.00	0.00	0.07	0.00	0.07
1B2	Fugitive Emissions from Natural Gas Transmission and Distribution	**CH_4**	1464.1	1804.7	50	10	50.99	7.07	-0.02	0.19	2.69	-1.09	2.90
4A	Enteric Fermentation	**CH_4**	1226.8	1350.9	20	40	44.72	4.64	-0.04	0.14	8.06	-0.70	8.09
4B	Manure Management	**CH_4**	99.8	118.2	20	50	53.85	0.49	0.00	0.01	0.88	-0.04	0.88
4F	Field Burning of Agricultural Residues	**CH_4**	3.6	7.4	50	20	53.85	0.03	0.00	0.00	0.02	0.01	0.03
6A	Solid Waste Disposal Sides	**CH_4**	863.1	879.9	30	30	42.43	2.87	-0.03	0.09	3.94	-0.97	4.06
6B1	Industrial Waste Water Handling	**CH_4**	29.4	44.1	56	58	80.77	0.27	0.00	0.00	0.38	0.02	0.38
6B2	Domestic Waste Water Handling	**CH_4**	231.0	235.2	5	43.6	43.89	0.79	-0.01	0.02	1.53	-0.04	1.53
1A1	Stationary Fuel Combustion (except biomass)	**N_2O**	5.08	7.84	8	100	100.32	0.06	0.00	0.00	0.12	0.00	0.12
1A2	Fuel Combustion (biomass)	**N_2O**	17.80	23.66	25	100	103.08	0.19	0.00	0.00	0.35	0.00	0.35

	A	B	C	D	E	F	G	H	I	J	K	L	M
	IPCC source-category	**Gas**	**Emissions of 2010**	**Emissions of 2013**	**Uncertainty of activity data**	**Uncertainty of emission factors**	**Combined uncertainty**	**Percentage of combined uncertainty of 2013 in total emissions**	**A type sensitivity**	**B type sensitivity**	**Uncertainty in national emissions due to uncertainty of emission factors**	**Uncertainty in national emissions due to uncertainty of activity data**	**Uncertainty trend in national emission**
1A3a	Civil Aviation	**N_2O**	0.00	0.02	8	100	100.32	0.00	0.00	0.00	0.00	0.00	0.00
1A3b	Road Transport	**N_2O**	6.20	6.51	8	50	50.64	0.03	0.00	0.00	0.05	0.00	0.05
1A3c	Other Transportation	**N_2O**	0.00	0.08	8	100	100.32	0.00	0.00	0.00	0.00	0.00	0.00
1A4a	Commercial and Public Services	**N_2O**	1.72	0.54	8	150	150.21	0.01	0.00	0.00	0.01	0.00	0.01
1A4b	Residential	**N_2O**	17.35	24.80	8	150	150.21	0.29	0.00	0.00	0.56	0.00	0.56
1A4c	Agriculture, Fishing and Forestry	**N_2O**	0.81	0.06	8	150	150.21	0.00	0.00	0.00	0.00	0.00	0.00
2B2	Nitric Acid Production	**N_2O**	795.80	824.41	5	20	20.62	1.31	-0.03	0.09	2.46	-0.14	2.46
3	Solvents and Other Product Use	**N_2O**	0.01	0.01	25	1	25.02	0.00	0.00	0.00	0.00	0.00	0.00
4B	Manure Management	**N_2O**	127.1	151.9	50	100	111.80	1.30	0.00	0.02	2.27	-0.12	2.27
4D1	Direct Soil Emissions	**N_2O**	564.0	663.0	20	100	101.98	5.19	-0.01	0.07	9.89	-0.24	9.90
4D2	Pasture Range and Puddock	**N_2O**	332.0	366.0	30	100	104.40	2.94	-0.01	0.04	5.46	-0.28	5.47
4D3	Indirect Emissions	**N_2O**	378.2	437.1	100	100	141.42	4.75	-0.01	0.05	6.52	-0.87	6.58
4F	Field Burning of Agricultural Residues	**N_2O**	3.1	3.1	50	20	53.85	0.01	0.00	0.00	0.01	-0.01	0.01
6B2	Domestic Waste Water Handling	**N_2O**	62.10	68.20	5	70	70.18	0.37	0.00	0.01	0.71	-0.01	0.71
2F	Consumption of Halocarbons and Sulfur Hexafluoride (Refrigeration and Air	**HFC**	137.50	208.03	5	25	25.50	0.41	0.00	0.02	0.78	0.01	0.78

	A	B	C	D	E	F	G	H	I	J	K	L	M
	IPCC source-category	**Gas**	**Emissions of 2010**	**Emissions of 2013**	**Uncertainty of activity data**	**Uncertainty of emission factors**	**Combined uncertainty**	**Percentage of combined uncertainty of 2013 in total emissions**	**A type sensitivity**	**B type sensitivity**	**Uncertainty in national emissions due to uncertainty of emission factors**	**Uncertainty in national emissions due to uncertainty of activity data**	**Uncertainty trend in national emission**
	Conditioning Equipments)												
2F	Consumption of Halocarbons and Sulfur Hexafluoride (Emissions from Appliances, Electrical Equipment)	**SF6**	0.22	0.28	5	100	100.12	0.00	0.00	0.00	0.00	0.00	0.00
	Total emissions:		**9478.38**	**13018.09**	**Emissions uncertainty**			**25.14**			**Uncertainty of trend**		**43.71**

ANNEX B: QUALITY ASSURANCE AND QUALITY CONTROL

Introduction

To ensure a high quality GHG inventories, the team preparing the Georgian GHG NIR guaranteed the transparency, completeness, consistency, comparability and accuracy of the information used by establishing a separate system for Quality Assurance and Quality Control (QA/QC). The QA/QC System in place adheres to the IPCC good practice guidelines for preparing GHG NIRs.

The QC is carried out through a system of routine technical activities that monitor and maintain the quality of the inventory, while it is being prepared. The QC activities are carried out by sector teams during the preparation of the sectorial GHG NIRs and also by the QA/QC expert/coordinator during the compilation and preparation of the GHG NIR of Georgia.

The QA is a system of planned review procedures implemented by staff members who are not directly involved in preparing the NIR or in compiling the NGHGI. Independent third parties are responsible for reviewing the sectorial and national inventories.

The QA/QC for Georgian national GHG inventory were performed for the first time and conducted by the external organization WEG, which is not directly involved in preparing the NIR.

The sections below briefly describe the QA/QC system implemented and general activities carried out during the compilation and preparation of the Georgian GHG NIR.

Elements of the QA/QC system

The QA/QC system for GHG NIR of Georgia was established according to the UNFCCC and Kyoto Protocol's provisions related to GHG inventory preparation and national system establishment, and also to the 1996 Revised IPCC Methodology and Good Practice Guidance. Therefore, the system comprises the following elements:

- Identifying of the objectives of the QA/QC;
- Preparation of the QA/QC Plan;
- The QC procedures;
- The QA procedures;
- The reporting, documenting and archiving procedures.

QA/QC Objectives

The objectives of the QA/QC activities on national greenhouse gas inventories are to improve transparency, consistency, comparability, completeness, accuracy, confidence and timeliness in national inventories.

The QA and QC must be integrated into every step of the inventory development process. Thus, undertaking checks and procedures at every stage of estimation and document development, involving the experts on an ongoing basis, maintaining an open and transparent inventory process, using multiple review processes, and providing for communication and feedback across the participants in the inventory, are all part of quality control and improvement. The objective also includes information feedback loops, and provides for corrective actions that are designed to improve the inventory estimates over time.

QA/QC plan

The QA/QC plan is a fundamental element of the QA/QC system. The plan is an internal document to organise, plan and implement QA/QC activities (please see Attached document). The plan, in general, outlines QA/QC activities that will be implemented, and includes a scheduled time frame that follows inventory preparation from its initial development through to final reporting in any year.

QA/QC activities

Prior to the compilation of sectorial inventories for the GHG NIR, the following activities were carried out:

- The Project Coordinator and QA/QC expert conducted an internal review of the preliminary numerical results of each SGHGIs.
- A qualified GHG inventory reviewer from one of the Parties conducted an external review of each SGHGIs.
- The findings and recommendations of the external review process were analyzed.
- The findings and recommendations for each sector were incorporated, where pertinent.
- A calculation spreadsheet was created and populated with numerical results for the national level following the 2006GL format. The spreadsheet included automated links from sectorial report files to prevent potential data entry errors. The spreadsheet also has a cross-checking function to ensure that the values on the sectorial and national inventories match.
- A calculation spreadsheet was created and populated with numerical results, in formats established in the GL-UNFCCC-BUR and GL-UNFCCC-NC. The spreadsheet was constructed by harmonizing the results of the 2006 GL format with the format required by the UNFCCC, using automated links to prevent potential data entry errors. The spreadsheet has a cross-checking function as well, to ensure that the values reported in the sectorial and national inventories match.
- A draft version of the Georgian NIR was produced and reviewed by sector teams.
- The draft version of the NIR was subjected to an internal review by the appropriate sectorial coordinator and QA/QC expert.
- On 22.01.16, an interim GHG NIR report was discussed and reviewed during the Stakeholders meeting.
- The chapter 7 Land Use, Land Use Change and Forestry (LULUCF) was separately reviewed by an International LULUCIEF expert (Iordanis Tzamtzis). Findings and comments were addressed and incorporated.
- On 25.03.16 a joint meeting with stakeholders, interested parties, and experts from different sectors, took place to review and discuss the Pre-final NIR and a presentation of the results by sectorial experts.
- The NIR was reviewed by an external expert (Dr. Carlos López, consultant in national GHG emissions inventories). The review was coordinated by the UNDP-UNEP Global Support Programme (GSP) and was conducted from 25 to 29 April 2016. The Review Report was positive; findings, comments and suggestions were addressed and incorporated where appropriate.

Once the process of reviewing was complete, the draft NIR was submitted to the National BUR/NC Coordinating Team, which prepared the report to be submitted to the UNFCCC.
For each sector the following general routine QA and QC procedures were performed:

<u>Quality control</u>

- Verification of the integrity of files in the database included:

    - A detailed review of each annual file of the BUR to ensure that all data specifications were correct;
    - The construction of a consolidated spreadsheet of activity data that uses automated links, to translate BNE values into the format required by the IPCC data entry software, to avoid manual data entry errors;
    - The cross-checking of data imported from the BNE to the annual consolidated spreadsheet, and then from the spreadsheet to the format required by the IPCC software.
- Verification of the consistency of GHG emission trends, identifying potentially anomalous activity data that could lead to anomalous emission values;
- Random comparison of results yielded by IPCC software and staff calculations;
- Comparison of results of the sectorial and reference approaches;
- Comparison of GHG emission results in the Sectorial reports with other GHG inventories;
- Verification and checking of uncertainty calculations.

All main Tier 1 Level QC Procedures and results are summarized in the Table below:

	TIER 1 GENERAL INVENTORY LEVEL QC PROCEDURES		
	QC Activity	**Procedures**	**Results**
1	Check that assumptions and criteria for the selection of activity data and emission factors are documented.	Descriptions of activity data and emission factors with information on source categories cross-checked.	Data and emission factors are properly recorded.
2	Check for transcription errors in data input and reference	• Confirm that bibliographical data references are properly cited in the internal documentation.	Data references are properly cited.
		• Cross-check a sample of input data from each source category (either measurements or parameters used in calculations) for transcription errors.	No transcription errors detected.
3	Check that emissions are calculated correctly.	• Reproduce a representative sample of emission calculations.	Done successfully.
		• Selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy.	Done successfully.
4	Check that parameter and emission units are correctly recorded and that appropriate conversion factors are used.	• Check that units are properly labeled in calculation sheets.	Checked.
		• Check that units are correctly carried through from beginning to end of calculations.	Units are correctly carried through calculations.
		• Check that conversion factors are correct.	Conversion factors are correct.
		• Check that temporal and spatial adjustment factors are used correctly.	Adjustment factors are used correctly.
5	Check the integrity of database files.	• Confirm that the appropriate data processing steps are correctly represented in the database.	Confirmed.
		• Confirm that data relationships are correctly represented in the database.	Confirmed.
		• Ensure that data fields are properly labeled and have the correct design	Data fields are properly labeled and have correct

	TIER 1 GENERAL INVENTORY LEVEL QC PROCEDURES		
	QC Activity	**Procedures**	**Results**
		specifications.	design specs.
		• Ensure that adequate documentation of database and model structure and operation are archived.	Documentation of database, model structure and operation are archived.
6	Check for consistency in data between source categories.	• Identify parameters (e.g. activity data, constants) that are common to multiple source categories and confirm that there is consistency in the values used for these parameters in the emission calculations.	Parameters that are common to multiple source categories are identified and values used for the parameters are consistent.
7	Check that the movement of inventory data among processing steps is correct.	• Check that emission data is correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries.	Emission data is correctly aggregated from lower to higher reporting levels of the summaries.
		• Check that emission data is correctly transcribed between different intermediate products.	Check performed successfully.
8	Check that uncertainties in emissions and removals are estimated or calculated correctly.	• Check that qualifications of individuals providing expert judgment for uncertainty estimates are appropriate.	Check performed successfully.
		• Check that qualifications, assumptions and expert judgments are recorded. Check that calculated uncertainties are complete and calculated correctly.	Qualifications, assumptions and expert judgments are recorded. Calculations are complete and correct.
		• If necessary, duplicate error calculations or a small sample of the probability distributions used by Monte Carlo analyses.	Was not necessary.
9	Undertake review of internal documentation.	• Check that there is detailed internal documentation to support the estimates and enable duplication of the emission and uncertainty estimates.	Check performed successfully.
		• Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review.	Inventory data, supporting data, and inventory records are archived and stored.
		• Check integrity of any data archiving arrangements of outside organisations involved in inventory preparation.	Data outside organisations involved in inventory preparation are archived according to their internal rules.
10	Check methodological and data changes resulting in recalculations.	• Check for temporal consistency in time series input data for each source category.	Checked.
		• Check for consistency in the algorithm/method used for calculations throughout the time series.	Checked.
11	Undertake completeness checks.	• Confirm that estimates are reported for all source categories and for all years from the appropriate base year to the period of the current inventory.	Confirmed where apropriete.
		• Check that known data gaps that result in incomplete source category emission estimates are documented.	Known data gaps resulted in incomplete source category are documented.
12	Compare estimates to previous estimates.	• For each source category, current inventory estimates should be compared to previous estimates. If there are significant changes or departures from	Each source category of current inventory estimates is compared to previous estimates. Significant

	TIER 1 GENERAL INVENTORY LEVEL QC PROCEDURES		
	QC Activity	**Procedures**	**Results**
		expected trends, recheck estimates and explain any difference.	changes/departures from expected trends, rechecked and differences are explained.

Quality assurance

In 2016, the Sectorial SGHGI and final draft of the NIR was reviewed by external experts qualified as reviewers of NGHGIs (see paragraph 1.3). The review was conducted remotely, with continuous communication between the reviewers, the project coordinator and professionals of the Sectorial Team, allowing issues to be resolved and addressed as they emerged. The sector team then analyzed the assessment report, corrected pertinent findings and evaluated the feasibility of incorporating the recommendations.

Continuous improvement plan

The QA/QC System includes a work plan to continuously improve the quality of GHG NIR. This ongoing effort seeks to identify potential areas for improvement and how these should best be implemented. Issues that arise are addressed on an ongoing basis by the Working Team during the coordinating meetings, or bilaterally between a particular sectorial team and the Project coordinator and the QA/QC expert.

ANNEX C: RECALCULATION OF GHG EMISSIONS FOR 2010-2011 AND POSSIBLE IMPROVEMENTS FOR FUTURE INVENTORIES

Energy Sector

In the energy sector recalculations of GHGs, emissions for 2010-2011 were largely based on updated information on coal and natural gas supply and consumption, and country specific net calorific values for some fuels - LPG, Anthracite, Lignite, Other Bituminous Coal, Coke Oven, Coking Coal, and Natural Gas, which were provided by GEOSTAT. A new source of emission, gas consumption for transit pipeline operations, was identified. The data was provided by British Petroleum Georgia. According to the good practice guideline, an updated conversion factor for calculating fugitive emissions from gas production was used (392800 kgCH4/PJ–Rabchuk). Data obtained from the Azoti factory, allowed to separate gas consumption for energy (46%) and non-energy (54%) purposes for ammonia production. In the previous inventory, the total amount of gas consumed by Azoti factory was accounted as non-energy use of natural gas.

Recalculations were done only for 2010-2011, due to a lack of data for previous years (1990-2009) and a time constraint. The GHG emissions, according to the third and the fourth (recalculated) national inventories, are provided in the Table below.

GHG emissions according to the third and the fourth (recalculated for FBUR) national GHG inventories

(Tonnes of CO_2 equivalent)

	Third GHG Inventory (TNC)		Recalculated (FBUR)		Changes	
Source-Category	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**
1A Fuel combustion	**5,280**	**6,342**	**5,916**	**7,395**	**12%**	**17%**
1A1 Energy Industries (Electricity and Heat Production)	539	1,218	542	1,220	0%	0%
1A2 Manufacturing Industries and Construction	580	1,071	891	1,630	54%	52%
1A3 Transport	2,419	2,331	2,574	2,537	6%	9%
1A4 Other Sectors (Commercial/ Residential/ Agriculture/ Fishing/ Forestry)	1,525	1,641	1,669	1,923	9%	17%
1A5 Other (not elswhere specified)	218	80	241	86	10%	7%
1B Fugitive Emissions	**1,697**	**2,458**	**1,542**	**2,018**	**-9%**	**-18%**
1B1. Solid Fuels	75	99	75	99	0%	0%
1B2. Oil and Natural Gas	1,622	2,359	1,467	1,919	-10%	-19%
Total from energy sector	**6,977**	**8,800**	**7,458**	**9,413**	**7%**	**7%**

As can be seen from the Table, significant changes occurred in the manufacturing industy, transport, other sectors and natural gas transportation sub sectors. The GHG emissions from the manufacturing industries increased based on the data provided by Azoti factory. Part (46% for heat generation) of the natural gas consumed for amonnia production, transferred to the industry sub-sector. In the transport sector, GHG emissions increased due to the emission from pipeline operations, a new source added. In other sectors, such as residential, commercial and agriculture, energy consumption data was corrected and emissions increased accordingly.

According to the information from the Ministry of Energy of Georgia, the thermal power plants receive gas through high pressure pipelines and, therefore, the amount of gas consumed by thermal power plants should not be included in the assessment of distribution losses. This was a problem in the previous inventory, which was corrected.

Possible Improvements for the Future Inventory in Energy Sector:

- For the next inventory it is recommended to use the 2006 guideline and to recalculate previous years;
- The National Statistics Office of Georgia will provide official, and more vigorous, energy balances for 2013 onwards, and additional information on technologies used for energy purposes will be accessible, which will allow the experts to use higher tier methods for the GHG emission invantories in energy sector;

Industrial Processes

Cement Production

The recalculation period covers two years: 2010 and 2011. The Tier 2 Method of the IPCC GPG 2000 was used to calculate emissions, instead of Tier 1. The use of clinker production data provides more accuracy, since clinker processing is the primary source of CO_2 emissions. The significant difference between the emission data in 2010 and 2011, mostly caused the various content of clinker in diverse types of cement produced by the different factories. Subsequently, since accurate data on the exact amount of cement produced disaggregated by types, and clinker content is not available, emissions calculated by using the Tier 1 method relates to the significant uncertainties.

	FBUR		TNC	
Source-Category	**2010**	**2011**	**2010**	**2011**
2A Cement Production	**255**	**489**	**536**	**983**

Lime Production

The methodology is mostly the same in both inventory reports. In case of the BUR report, the hydrated lime correction factor was used, since lime processing in Georgia is based on the wet method. The significant difference in emissions in 2011 is, mainly, caused by the change in activity data. In 2010, the data was provided by GEOSTAT, and in 2011 the data was collected by an expert visiting the factory.

	FBUR		TNC	
Source-Category	**2010**	**2011**	**2010**	**2011**
2A2 Lime Production	**35**	**721**	**37**	**40**

Limestone and Dolomite Use

Emissions from Limestone and Dolomite use is calculated in the 2A1 Cement Production and 2A7 Glass Production sectors. Here, emissions from limestone use in the steel processing are presented. The calculation method is the same as in the NC report. In order to avoid double counting, the limestone used in clicker production and glass making does not cover in this source-category.

	FBUR		TNC	
Source-Category	**2010**	**2011**	**2010**	**2011**
2A3 Limestone and Dolomite Use	**0.44**	**1.18**	**3.78**	**3.78**

Chemical Industry

Ammonia Production

The Tier 1a methodology was used for calculations, instead of Tier 1b. The slight difference in emissions in 2010 and 2011 is mostly caused by the changes in methodology.

	FBUR		TNC	
Source-Category	**2010**	**2011**	**2010**	**2011**
2B1 Ammonia Production	**214**	**242**	**285**	**277**

Nitric Acid Production

There are no changes in the methodology used. The slight difference in emissions in 2011 is mostly caused by the changes in activity data.

	FBUR		TNC	
Source-Category	**2010**	**2011**	**2010**	**2011**
2B2 Nitric Acid Production	**795.8**	**818.2**	**796.7**	**722.3**

Metal Production

Iron and Steel Production

There is a considerable difference in emissions between the TNC and FBUR reports. In the latest report, the Tier 2 method was used to calculate emissions from the steel processing source-category. By taking into account the national circumstances, it is relevant to calculate emissions

from the EAF process, since there is no cast iron making. Only the rust manufacturing process is available in Georgian Steel factories by using EAF. Hence, the method meets the current situation in Georgia completely, and emissions are calculated by using factory specific activity data (see confidential materials).

	FBUR		TNC	
Source-Category	**2010**	**2011**	**2010**	**2011**
2C1 Iron and Steel Production	**3.3**	**10.7**	**270**	**341**

Ferroalloys Production

There are no changes in the methodology used. The slight difference in emissions in 2011 is mostly caused by the changes in activity data.

	FBUR		TNC	
Source-Category	**2010**	**2011**	**2010**	**2011**
2C2 Ferroalloys Production	**336**	**401**	**346**	**413**

Consumption of Halocarbons and Sulphur Hexafluoride

Compared to the NC report, emissions from HFC consumption were calculated for four different gases separately. The activity data was collected from customs service, which is the only legal way to import the compounds. Since relevant, accurate statistic information on refrigerators, air conditioners, and fire distinguishers does not exist in Georgia, approximation results in a significantly high uncertainty. Accordingly, to estimate potential emissions, the activity data were collected from customs services and covered the HFCs mostly used as refrigerant agents.

There are no changes in the methodology used for to calculate SF_6 emissions.

	FBUR		TNC	
Source-Category	**2010**	**2011**	**2010**	**2011**
2F1 Refrigeration and Air Conditioning Equipment	**137.5**	**238.2**	**631.6**	**803.5**
2F6 SF_6 Emissions from Appliances	**0.2232**	**0.252 1**	**0.2232**	**0.252 1**

Agriculture

Recalculations in the agriculture sector are provided in chapter 6.

Waste

Recalculations in the waste sector are provided in chapter 8.

Land use, land use change and forestry (LULUCF)

The recalculations for the 2010-2011 LULUCF sector, show no significant changes between the updated and old estimations, excluding several sub-sectors. Overall, changes range between (-1)-(+40)%. The recalculations were the result of, mainly, updated data used. Data received for sectors from different sources were corrected. For example, in the forestry sector the data underwent corrections according to the materials received from the National Forestry Agency and Ajara Forestry Agency, particularly the data regarding logging.

GHG emissions according to the third and the fourth (recalculated for FBUR) national GHG inventories

Source-Category	GHG	Third GHG Inventory (TNC)		Recalculated (FBUR)		Changes	
		2010	2011	2010	2011	2010	2011
Forest Land	Gg CO_2	-5 770.0	-6 088.0	-5 207	-5 597.3	-10%	-8%
Cropland/ Annual Croplands	Gg CO_2	-121.0	-121.0	-169.9	-118.3	40%	-2%
Cropland/ Perennial Woody Crops	Gg CO_2	269.0	-885.0	-962.5	-962.5	458%	9%
Grassland (Hayfields and Pastures)	Gg CO_2	2 470.0	2 470.0	2 470.2	2 470.2	0%	0%
Net Emission/ rRmovals	Gg CO_2	-3 151.0	-4 624.0	-3 869.2	-4 208.0	23%	-9%

As for other sub-sectors, as it is shown in the Table, the main changes in emissions/removals (2010) were caused by updated perennial plantations in agricultural lands (458%) data, as a result of corrections made in the FAOSTAT data.

Possible Improvements for future inventory in the LULUCF Sector:

- The IPCC 2006 Guidelines should be applied in the future; since the accuracy of calculations will increase.
- The current forest inventory in the forestry sector should have updated data;
- The default coefficients in the 2006 methodology should be revised and specified. As new coefficients will improve calculations and data.

ANNEX D: ENERGY BALANCES FOR 2010-2013 YEARS

Energy Balance of Georgia - 2010

Fuel	Crude Oil	Gasoline	Jet Kerosene	Other Kerosene	Diesel Oil	Residual Fuel oil (mazut)	LPG	Bitumen	Lubricants	Other Oil	Lignite	Other bituminous coal	Coke Oven Coke	Firewood	Natural gas	Hydro	Electricity
Unit	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	1000 cubic meters	Million cubic meters	GWh	GWh
Production	51										268			2,004	8	9,375	
Import	5	436	39	64	418	4	17	93	15	2		67	97		6,966		222
Export	(58)	(0)		(0)	(0)	(4)		(0)	(0)	(0)	(15)				(5,796)		(1,524)
International aviation bunker			(39)														
International marine bunker																	
Stock changes	2								(4)	(2)							
Total primary energy	**(0)**	**436**	**-**	**64**	**418**	**1**	**17**	**93**	**10**	**(0)**	**253**	**67**	**97**	**2,004**	**1,179**	**9,375**	**(1,302)**
Transformation	**-**	**-**	**-**	**-**	**(53)**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**(306)**	**(9,375)**	**9,022**
Electricity generation (GAS TPP)					(53)										(198)		683
Electricity generation (HPP)																(9,375)	9,375
Distribution losses															(86)		(859)
Transportation losses															(22)		(177)
Total final energy	**-**	**436**	**-**	**64**	**365**	**1**	**17**	**93**	**10**	**-**	**253**	**67**	**97**	**2,004**	**872**	**-**	**7,700**
Industry		6				0					61	67	97		163		2,387
Transport, among them	-	418	-	-	339	-	-	-	-	-	-	-	-	-	16	-	385
Road transport		417			334										8		
Rail transport		1			4												385
Civil aviation																	
Pipelines															8		
Residential				64	6		17							1,741	413		1,980
Commercial and Public Services														173	110		1,553
Agriculture / fishing / forestry		12			20						64				45		18
Other (unspecified)						0					128			89	10		1,377
Non-energy use								93	10						117		

Energy Balance of Georgia - 2011

Fuel	Crude Oil	Gasoline	Jet Kerosene	Other Kerosene	Diesel Oil	Residual Fuel oil (mazut)	LPG	Bitumen	Lubricants	Other Oil	Lignite	Other bituminous coal	Coke Oven Coke	Firewood	Natural gas	Hydro	Electricity
Unit	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	1000 cubic meters	Million cubic meters	GWh	GWh
Production	50										353			1,759	6	7,892	
Import	3	402	57	57	428	6	19	60	14	0	0	81	129		7,127		471
Export	(49)				(0)			(0)	(1)		(7)				(5,277)		(931)
International aviation bunker			(35)														
International marine bunker																	
Stock changes	(4)		(4)							(0)							
Total primary energy	**0**	**402**	**18**	**57**	**428**	**6**	**19**	**60**	**14**	**-**	**346**	**81**	**129**	**1,759**	**1,856**	**7,892**	**(460)**
Transformation	-	-	-	-	**(12)**	-	-	-	-	-	-	-	-	-	**(770)**	**(7,892)**	**9,412**
Electricity generation (GAS TPP)					(12)										(629)		2,212
Electricity generation (HPP)																(7,892)	7,892
Distribution losses															(107)		(889)
Transportation losses															(34)		196
Total final energy	**-**	**402**	**18**	**57**	**416**	**6**	**19**	**60**	**14**	**-**	**346**	**81**	**129**	**1,759**	**1,086**	**-**	**8,526**
Industry					18	6					302	81	129		232		2,564
Transport, among them	-	402	18	-	315	-	-	-	-	-	-	-	-	-	19	-	389
Road transport		402			315										14		
Rail transport																	389
Civil aviation			18														
Pipelines															5		
Residential				46	20		13							1,479	484		2,150
Commercial and Public Services							2							190	181		1,786
Agriculture / fishing / forestry				11	64		4								38		24
Other (unspecified)											43			89	6		1,613
Non-energy use								60	14						126		

Energy Balance of Georgia - 2012

Fuel	Crude Oil	Gasoline	Jet Kerosene	Other Kerosene	Diesel Oil	Residual Fuel oil (mazut)	LPG	Bitumen	Lubricants	Other Oil	Lignite	Other bituminous coal	Coke Oven Coke	Firewood	Natural gas	Hydro	Electricity
Unit	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	1000 cubic meters	Million cubic meters	GWh	GWh
Production	44										422			3,967	5	7,221	
Import		384	51	51	459	3	18	102	18	0		76	131		7,232		615
Export	(37)				(0)	(1)			(1)		(4)				(5,200)		(528)
International aviation bunker			(68)														
International marine bunker																	
Stock changes	(7)		18														
Total primary energy	**(0)**	**384**	**1**	**51**	**459**	**2**	**18**	**102**	**17**	**0**	**418**	**76**	**131**	**3,967**	**2,038**	**7,221**	**86**
Transformation	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**(854)**	**(7,221)**	**8,671**
Electricity generation (GAS TPP)															(702)		2,477
Electricity generation (HPP)																(7,221)	7,221
Distribution losses															(117)		(848)
Transportation losses															(36)		(179)
Total final energy	**-**	**384**	**1**	**51**	**459**	**2**	**18**	**102**	**17**	**0**	**418**	**76**	**131**	**3,967**	**1,183**	**-**	**8,746**
Industry		9		1	57	1					416	76	131		256		2,907
Transport, among them	-	374	1	-	394	-	2	-	-	-	-	-	-	-	25	-	382
Road transport		374			384		2								25		
Rail transport					9												382
Civil aviation			1														
Domestic Navigation					1												
Pipelines																	
Residential				39			15				1			3,630	490		2,161
Commercial and Public Services						1	0				0			335	277		1,725
Agriculture / fishing / forestry		1		12	8									2	4		37
Other (unspecified)																	1,534
Non-energy use								102	17	0					133		

Energy Balance of Georgia - 2013

Fuel	Crude Oil	Gasoline	Jet Kerosene	Other Kerosene	Diesel Oil	Residual Fuel oil (mazut)	LPG	Bitumen	Lubricants	Other Oil	Antracite	Lignite	Other bituminous coal	Coke Oven Coke	Firewood	Natural gas	Hydro	Electricity
Unit	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	1000 cubic meters	Million cubic meters	GWh	GWh
Production	48											404			2,543	5	8,271	
Import		376	88	0	476	5	17	78	17	0	8		70	155		8,013		484
Export	(57)	(2)			(0)	(5)		(1)	(2)			(4)				(6,100)		(450)
International aviation bunker			(85)															
International marine bunker																		
Stock changes	9	8	(3)		(14)	1	(0)	2				1		(10)	0			
Total primary energy	**-**	**383**	**1**	**0**	**461**	**1**	**17**	**79**	**15**	**0**	**8**	**401**	**70**	**145**	**2,543**	**1,919**	**8,271**	**34**
Transformation	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**(1)**	**-**	**-**	**-**	**(638)**	**(8,271)**	**9,051**
Electricity generation (GAS TPP)																(505)		1,788
Electricity generation (HPP)																	(8,271)	8,271
Distribution losses																(127)		(805)
Transportation losses																(6)		(204)
Total final energy	**-**	**383**	**1**	**0**	**461**	**1**	**17**	**79**	**15**	**0**	**8**	**399**	**70**	**145**	**2,543**	**1,281**	**-**	**9,075**
Industry		9		0	58	1					7	398	70	145	1	207		2,327
Transport, among them	-	374	1	-	395	-	2	-	-	-	-	-	-	-	-	261	-	282
Road transport		374			385		2									261		
Rail transport					9													282
Domestic aviation			1															
Domestic Navigation					1													
Pipelines																		
Residential				0			14					1			2,501	532		2,253
Commercial and Public Services						1	0				0	0			41	133		2,572
Agriculture / fishing / forestry		1			8										0	2		35
Other (unspecified)																6		1,605
Non-energy use								79	15	0						141		

	2010	2011	2012	2013
Natural gas consumed by BP for pipeline operations (mln. M3)	89.05	102.78	96.80	90.06

ANNEX E: LIVESTOCK POPULATION IN 2010-2013

	2009	2010				2011				2012				2013			
	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Cattle	1,081	1,118	1,125	1,094	1,018	1,111	1,126	1,068	1,055	1,167	1,179	1,145	1,095	1,205	1,264	1,213	1,193
		1,100	1,122	1,110	1,056	1,064	1,118	1,097	1,062	1,111	1,173	1,162	1,120	1,150	1,234	1,238	1,203
		1,096.8				**1,085.3**				**1,141.3**				**1,206.3**			
Buffalo	33	35	35	34	31	34	35	33	33	36	36	35	34	37	39	38	37
		34	35	34	33	33	35	34	33	34	36	36	35	36	38	38	37
		33.9				**33.6**				**35.3**				**37.3**			
Sheep	602	795	783	707	597	752	760	677	577	802	828	753	688	902	972	879	796
		699	789	745	652	674	756	719	627	689	815	791	721	795	937	925	837
		721.2				**694.1**				**753.8**				**873.7**			
Coats	72	76	75	68	57	70	71	63	54	63	65	60	54	69	74	67	61
		74	75	71	62	63	70	67	58	58	64	62	57	62	72	71	64
		70.7				**64.7**				**60.6**				**67.0**			
Swine	246	132	166	197	110	94	136	172	105	156	191	261	204	308	321	326	191
		189	149	182	154	102	115	154	139	131	174	226	233	256	315	324	259
		168.3				**127.4**				**190.7**				**288.2**			
Poultry	6,675	6,500	10,966	8,855	6,522	6,038	9,792	8,452	6,360	6,421	11,154	8,790	6,159	6,607	10,682	8,571	6,770
		6,587	8,733	9,911	7,688	6,280	7,915	9,122	7,406	6,391	8,788	9,972	7,475	6,383	8,645	9,627	7,670
		8,229.8				**7,680.7**				**8,156.2**				**8,081.1**			