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Air Quality Governance in the ENPI East Countries

"Draft Report on Preliminary Air Quality Assessment for Georgia"

Activity 2 Report

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Summary

PROJECT TITLE:	Preliminary Air Quality Assessment for Georgia
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COUNTRY:	Georgia

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CONTENTS

1. LIST OF ABBREVIATIONS AND ACRONYMS

Atmospheric Dispersion Modelling System	ADMS
Above Sea Level	a.s.l.
Degrees Celsius (centigrade)	^0C
Carbon Monoxide	CO
Methane	CH_4
Caucasus Environmental NGO Network	CENN
European Union	EU
European Neighbourhood Partnership Initiative	ENPI
Lead	Pb
Maximum Allowable Concentration	MAC
Metre	m
Millimetre	mm
Micrograms per cubic metre	$\mu g/m^3$
Milligrams per cubic metre	mg/m^3
Manganese dioxide	MnO_2
Ministry of Environmental and Natural Resources Protection	MoENRP
National Environmental Agency	NEA
Nitrogen dioxide	NO_2
Nitrogen oxides	NO_x
Non-methane volatile organic compounds	NMVOC
Ozone	O_3
Particulate Matter	PM
SEAP	Sustainable Energy Action Plan
Square kilometre	km^2
Sulphur dioxide	SO_2
Tonnes per year	t/y
Total Suspended Particulates	TSP
Volatile organic compounds	VOC

2. SUMMARY

2.1 Purpose of this Document

This report describes the preliminary assessment of air quality throughout Georgia, based on Air Quality modelling and to a limited extent historical monitoring data. This preliminary assessment covers the nine pollutants (SO_2, NO_2, NO_x, PM_{10}, $PM_{2.5}$, lead, benzene, CO, and ozone) considered within the EU Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe (the CAFE Directive).

Monitoring data has been supplied from the National Environment Agency (NEA) national monitoring network between 2008-2012, this has been supplemented by modelling data using ADMS-URBAN. Additional monitoring data in the form of passive diffusion tube sampling is also available.

Recommendations have been made for the number, location and area of zones and agglomerations, as well as the location of suitable monitoring sites to achieve compliance with the CAFE Directive. The number of sampling sites required within a zone or agglomeration depends on the population and the status of observed concentrations relative to the assessment thresholds within the zone. In time, these sampling sites may be reduced if suitable supplementary data, such as modelling data, becomes available.

Air quality modelling has an important place in the preliminary assessment process. It provides supplementary information on the following:

- Spatial Distribution for Assessment
- Designation of Zones
- Optimised Monitoring Networks
- Action Plans
- EU Threshold and limits

The use of air quality modelling enhances the ability to map the spatial distribution of the pollutant concentrations on different scales (from regional background to urban background and to the street level). Thus, it can provide data for an indicative checking of compliance/ non-compliance of limit values and an assessment in relation to lower and upper assessment thresholds.

3. INTRODUCTION

3.1 Background and Scope of the Report

The Air Quality Governance project in (ENPI) East Countries is currently assisting Georgia in preparing and implementing a national pilot project to perform a feasibility study on the designing of a national air quality monitoring system. The intention is that the pilot project will allow Georgia to develop a national monitoring network and set relevant guidelines with the aim to that Georgia can begin to design air quality planning measures which allow it to comply with EU standards.

The objective of the feasibility study is to seek to improve Georgia's current air quality legislation, ambient air quality monitoring network as well as the assessment and reporting of ambient air quality data. Overall the intention is to prepare the ground upon which Georgia can begin to bring its legislative framework and ambient monitoring practices into line with those of with European legislation and regulations respectively. Should the feasibility prove a success, it will contribute to improved air quality within Georgia, whilst strengthening the implementation and compliance of national air quality regulation and improvements.

This preliminary assessment represents the second component/deliverable of the National Pilot Project feasibility study. It is a baseline air quality assessment for Georgia, and will apply the requirements of the EU air quality directives and will be based on the existing data and resources available in Georgia.

The purpose of this Preliminary Assessment is to assess the pollution levels in order to define zones and determine the assessment requirements, so information related to health or exposure is not included. Therefore this preliminary air quality assessment is an overall study of the pollution sources and emissions in Georgia, by zones and agglomerations. It includes an analysis of existing ambient air quality monitoring and short-term passive sampling data generated under this study, spatial distribution of pollution concentration based on modelling of emission dispersion using ADMS-URBAN, exceedances of EU air quality limit values and the analysis of causes for any exceedances, should they occur. This assessment shall report strictly to EU limit values, lower and upper assessment thresholds in order to inform the requirement for monitoring of the relevant species. The report serves for designating zones and agglomerations and providing background for monitoring network design. The detailed air quality assessment for the city of Tbilisi shall be included in the Activity 3 report of this project.

4. METHODOLOGY FOR PRELIMINARY AIR QUALITY ASSESSMENT FOR GEORGIA

4.1 INTRODUCTION

Air quality assessments can be conducted using one or all of three main assessment tools or methods, these are:

- Air Quality Measurements
- Air Emissions Inventories
- Air Pollution Dispersion Models.

Air quality monitoring can be used to directly assess air pollution at locations either where limit values are at risk of being exceeded or information on emissions sources is unable. Where it is available, indicative measurement data can be used to complement one of the above tools or methods. Care should be taken to ensure only good quality input data is used for modelling, as major uncertainties can be introduced if monitoring data has been used from uncalibrated instrument, or is of unknown or poor quality.

4.2 METHOD AND APPROACH

For this assessment the air quality monitoring data collected by the National Environment Agency (NEA) for 2008-2012, from long term measurements were used. The major uncertainties of the measured air quality data presented in this report are influenced by the non-reference sampling and detection methodologies used, chosen sampling durations falling outside of those applicable to CAFE directive limit values, lack of correction and validation of data.

This assessment is based on the desk study of ambient air quality in Georgia.
Data used included:

i) emission inventories data compiled by the Air Protection Service of the Ministry of Environmental and Natural Resources Protection of Georgia (MoENRP) based on CORINAIR emission inventory methodology and emission registration forms;

ii) desk study and analysis of existing data on transport and municipal gas consumption patterns contained in Sustainable Energy Action Plans for Tbilisi, Rustavi and Batumi and Emission Inventory and Preliminary Modelling Study for Tbilisi;

iii) Long-term and short-term modelling of pollutants' concentrations based on ADMS-Urban(detailed information on emission inventories and modelling for Tbilisi is included in the separate report 3).

The assessment proposes the number and territory of zones and agglomerations and the structure of a national monitoring network which fulfils CAFE directive requirements. These requirements are listed in Table 1.

For pollutants except ozone (for which there is no limit values or assessment thresholds), the exceedance status has been determined using valid measured and modelled data available over a six year period 2008-2013 and based on guidance provided by Annex II, Section B of the CAFE Directive.

A formal exceedance was deemed to have occurred if there was an exceedance of the assessment threshold on three or more years during the six year period, 2008-2013.

In determining an exceedance of the assessment threshold, precedence has been given to measurement data where this is available, unless higher concentrations are predicted elsewhere by model outputs.

According to Article 7, Section 3 of the CAFE Directive, and the sampling criteria presented in Annex V, Table 1 of the CAFE Directive, the number of monitoring stations maybe reduced by up to 50 % where information other than fixed measurements is available.

For NO_2 and PM_{10} the assessment is based on the annual average threshold. For sulphur dioxide, the assessment is based on the 24-hour assessment threshold. For ozone, the minimum number of sampling sites is provided in Article 10 and Annex IX of the CAFE Directive.

The preliminary assessment method for $PM_{2.5}$ differs from that that for other pollutants since there is no datasets upon which to calculate assessment thresholds. In this case, the network size is based on the minimum number of sampling sites to assess compliance with the exposure reduction target (see Annex V, Section B of the CAFE Directive).

No monitoring is required in cases where the ambient concentration is less than the lower assessment threshold.

4.3LIMITATIONS AND UNCERTAINTIES

4.3.1 Inventories

Emission inventories can supply valuable information on pollution sources and their emissions, as well as emission fluxes across a whole zone. Often, the first estimates of air quality limit values being exceeded are derived from emission inventory data. However emission inventories can be deficient, containing data which is either based uponincorrect emission factors or historic activity figures.

Emission inventories can suffer from a lack of fundamental information. Emission factors can be difficult to obtain for certain sectors, and within this report, national emission inventory data is one of the major sources of uncertainty. For most of the sectors emission quantities are calculated taken into account default emission factors from CORINAIR Guidelines. There is a clear need of improved coverage of emission data especially forroad vehicles, the oil and gas sector as well as domestic heating. This will provide more comprehensive information on sources and emissions per zone.

4.3.2 Measurement Data

Where stationary measurements are not representative of pollution occurring at nearby receptors additional uncertainties are also introduced. As the air quality close to receptors may be substantially different from air quality at the station, or the limited measurement time coverage may not have captured significant variations in pollutant concentrations. Further uncertainty may be introduced in the calibration of the monitoring equipment and the potential for instrument drift over time.

4.3.3 Modelling

Dispersion models attempt to correlate air quality from known or estimated emissions, and can usefully relate where limit values have been exceeded across defined areas. Dispersion models are also useful in determining how air quality can be managed and improved within a zone.

Care should be used when handling modelling data as uncertainty often arises as a result of poor quality input data or due to uncertainty in input data especially related to meteorological and emission data. The main uncertainties of the modelling results used in this assessment report are linked to availability of reliable traffic frequency data and emission factors to calculate the emissions from traffic, correctness and completeness of the point source emission data as well as the quality of the meteorological observation data.

4.3.4 Zones and Agglomerations

Information on spatial distribution of pollutants may help in designating zones.

Air quality modelling provides valuable information when designing the national monitoring network. It predicts the areas where maximum exposure to air pollutants may occur and where air pollution may be presented in lower concentrations. This allows the number of monitoring stations to be reduced where pollutants are below the lower assessment threshold thus allowing an optimised cost-effective air quality network to be established. The combined use of monitoring and modelling is an essential part of the overall strategy within the EU CAFE Directive.

Where exceedances of pollutants limit values occurs a member state is required to prepare an action plan to demonstrate that limit values will be met.

4.3.5 Zones and assessment Regime

Through modelling the contribution of various sources and source categories to exceedances of limits values can be established. Air quality modelling has been used to calculate the source emission reduction required to comply with limit values from emission sources.

The requirement to use monitoring, modelling or a combination of both within air quality assessments is demonstrated in Figure 1. The different regimes refer to different requirements for assessment methods.

This preliminary assessment will attempt to describe the zones and agglomerations and the assessment requirements within each of the zones.

In agglomerations and in zones where pollutant concentrations exceed the upper assessment threshold (Table 1) monitoring is mandatory.

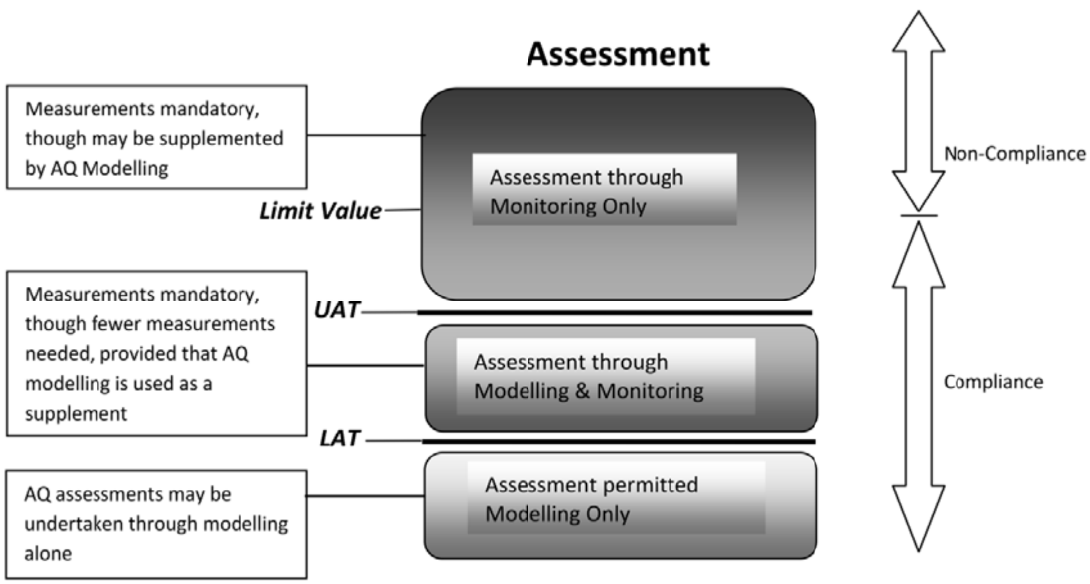
Table 1 EU Limit Values, lower assessment thresholds (LAT), upper assessment thresholds (UAT) and averaging periods for the various pollutants

Pollutant	Limit Value (LV) $\mu g/m^3$	Lower Assessment Threshold (LAT) % of LV	Upper Assessment Threshold (UAT) % of LV	Averaging Period	Statistics	Protection of
NO_2	200	50%	70%	1 hour	18 times per year	Human health

	40	50%	65%	Calendar year	Annual Mean	Human health
NOx	30	65	80	Calendar year	Annual Mean	Vegetation
SO_2	125	40	60	24 hrs	3 times per year	Human health
	20	40	60	Calendar yearandwinter (1Octoberto31March)	Mean annual and Winter	Ecosystems
Particles (PM_{10})	50			24 hr	35 times per year	Human health
	40			Calendar year	Annual mean	Human health
Particles ($PM_{2.5}$)	25	50	70	Calendar year	Annual Mean	Human health
Lead	0.5	50	70	Calendar year	Annual Mean	Human health
Benzene	5	40	70	Calendar year	Annual Mean	Human health
CO	10,000	50	70	8 hrs (running)	Maximum	Human health

Where pollutant concentrations are below the upper assessment threshold the number of monitoring stations can be reduced and supplemented by modelling. Where pollutant concentrations are below the lower assessment threshold assessment can be undertaken using modelling alone.

Figure 1 Air Quality EU Assessment Thresholds



5. AIR QUALITY DATA GENERATED AT EXISTINGMONITORING NETWORK OF GEORGIA

5.1 Current Air Quality Data Reporting

Air Quality data measurements in Georgia have historically been reported as monthly average concentrations of air pollutants. These are reported within monthly bulletins and are available at NEA-s web-site (http://meteo.gov.ge/radiation). Current reports cover the period from February 2013 through May 2014. Bulletins for previous years are stored at NEA's office and are not currently available for the general public.

Continuous monitoring at the Tbilisi station began in June,2013, and data from this air quality monitoring station is presented in summary.

Passive Monitoring

From June 28 to July 12, 2014, air quality across Georgia was monitored using diffusion tube passive sampling at a total of 63 locations.

Table 2Passive Samples distributed across Georgia 2014

Passive Sample Species	Tbilisi	Rustavi	Zestaponi	Batumi	Kutaisi	Poti	Tchiatura	Total number of sites
NO_2	34	7	5	4	4	4	2	**60**
O_3	2	1	2	3	2	1	0	**11**
Benzene	0	0	0	1	0	1	0	**2**
City Total	**36**	**8**	**7**	**8**	**6**	**6**	**2**	**73**

Long termAir Quality Monitoring Results

The summary data provides information where pollution concentrations have fallen below the MACs.

Detailed information on Georgia's monitoring system is included in the Report 1"Comparison of the Air Quality Monitoring Systems of EU and Georgia"[1].

Table 3, below, contains a summary of the annual average concentrations of all pollutants monitored within the air quality network located across 5 Georgian cities. Sampling at these locations has been performed since 2008. With the exception to Tbilisi, air was sampled from

[1] http://w3.cenn.org/wssl/uploads/Comparison%20of%20the%20Air%20Quality%20Monitoring%20Systems%20of%20EU%20Members%20States%20and%20Georgia%20Final.docx

only one sampling site per city. Therefore currentlyreported concentrations of ambient airshould be viewed as the ones representing only part of the airshed within each city and they do not characterise whole ambient air environment.

Table 3. 2008-2013 Urban Air Quality Trend[2]

Pollutant	Annual Mean, µg/m^3						Georgia MACs, µg/m^3		EU Limit values
	2008	2009	2010	2011	2012	2013 *	Max (20-30 min.)	Dailyaverage (24 hours)	
Batumi									
Dust[3]	500	500	890	630	490	453			
SO_2	90	100	69	70	110	138	500	50	One day[4] 125 µg/m^3 One hour[5] 350 µg/m^3
CO	-	-	3,860	2,700	2,900	2,204	5,000	3,000	Maximum daily eight hour mean 10,000 µg/m^3
NO_2	120	100	97	130	139	147	200	40	Annually 40 µg/m^3 One hour 200 µg/m^3
Zestaponi									
Dust	550	500	490	480	460	415	150	50	
SO_2	112	110	120	120	120	127	500	50	One day[3] 125 µg/m^3 One hour[4] 350 µg/m^3
CO			1,650	1,680	1,350	1,350	5,000	3,000	Maximum daily eight hour mean 10,000 µg/m^3
NO_2	50	40	44	47	46	46	200	40	Annually 40 µg/m^3 One hour 200 µg/m^3
MnO_2	8.9	8.0	6.9	7.7	6.8	5.0	10	1	
Rustavi									
CO	3,200		2,680	3,300	3,700	3,478	5,000	3,000	Maximum daily eight hour mean 10,000 µg/m^3
NO_2	80		49	84	103	113	200	40	Annually 40 µg/m^3 One hour 200 µg/m^3
Kutaisi									
Dust	970	900	750	890	900	760	150	50	

[2]Source: Ambient Air Pollution Yearbook, 2012, National Environmental Agency. saqarTvelosteritoriazeatmosferulihaerisdabinZurebisweliwdeuli. garemoserovnulisaagentosgaremosdabinZurebismonitoringisdepartamentismonacemebi. 2012 weli

[3]In Georgia TSP are measured, while EU limit value concerns PM_{10}

[4] Not to be exceeded more than 3 times a calendar year

[5] Not to be exceeded morethan24times a calendar year

SO_2			150	150	180	196	179	500	50	One day[3] 125 µg/m³ One hour[4] 350 µg/m³
CO				4,660	4,900	4,800	3,182	5,000	3,000	Maximum daily eight hour mean 10,000 µg/m³
NO_2		95	90	99	130	140	122	200	40	Annually 40 µg/m³ One hour 200 µg/m³
Nitrogen Oxide		70	70			120	110	400	60	
Tbilisi										
Dust	Kvinitadze St.	780	500	430	500	500	693	150	50	
SO_2	Kvinitadze St.	130	120	98	90	90	119	500	50	One day[3] 125 µg/m³ One hour[4] 350 µg/m³
CO	Kvinitadze St.	5,100	4,000	3,600	2,800	2,970	3,333	5,000	3,000	Maximum daily eight hour mean 10,000 µg/m³
	Moscow Ave.					2,600	2,557	5,000	3,000	
	Tsereteli Ave					4,200	4,884	5,000	3,000	
NO_2	Kvinitadze St.	60	70	92	88	89	100	200	40	Annually 40 µg/m³ One hour 200 µg/m³

Passive Air Quality Monitoring Results

Passive sampling results (Appendix B) illustrate that NO_2 concentrations appear to vary widely across the country ranging from 1.04 μg/m^{3}at a Cemetery site in Kutaisi to 94.03 μg/m^{3}at the Tbilisi - Rustaveli Avenue site (Roadside).All passive sampling was done over two weeks, from June 28th to the 12th of July.

Across Georgia, passive sampling for NO_2revealed that 4 sites had NO_2 concentrations greater than 60 μg/m^3 (the exceedance of hourly limit 200 μg/m^{3}might be at risk), 12sites had NO_2 concentrations between 40 and 60μg/m^3, 4 sites had NO_2concentrations between 36 and 40 μg/m^3, and 38 sites had NO_2 concentrations less than 36 μg/m^3.

Out of the 16 sites with NO_2concentrations higher than 40 μg/m^3, 14 were within Tbilisiitself, implying that Tbilisi has a high occurrence of high NO_2 concentrations. However, this reflects the bias that 38 out of 58 NO_2 sampling sites were located within Tbilisi.

Passive benzene sampling results(Appendix B) indicate that ambient concentrations might be below the EU annual limit value of 5.0 μg/m^3.Benzene concentrations ranged from 0.85 to 4.03μg/m^3.

Passive monitoring of ozone has suggested that ozone concentrations are elevated at the selected sample sites. Average 2-weeksozone concentrations at the sample sites ranged between 62.59 to 160.99 μg/m^3. This suggests that the EU ozone limit value of 120μg/m^{3}that cannot be exceeded more than 25 days per calendar year averaged over 3 years, may be at risk of exceedence at least at one passive sampling site.

5.2Analysis of Ambient Air Quality Monitoring Data

Analysing monthly average ambient concentrations (Table 4 below) of pollutants for February 2013-February 2014, we can conclude that Georgian daily average MAC for NO_2 (40μg/m^3) which is consistent with EU annual average limit value was regularly exceeded at all monitoring sites, mostly attributed to vehicle emissions. Similarly, SO_2 Georgian daily average MAC (50μg/m^3) was exceeded every month at all monitoring sites, where this pollutant was measured (all cities except for Rustavi). EU limit values for SO_2(125 μg/m^3 daily average and 20μg/m^3 annual mean)were also exceeded regularly at all sites. Furthermore, TSP concentrations exceeded Georgian daily average MAC (50μg/m^3) every month at all monitoring sites, where this pollutant was measured (TSP was not measured in Rustavi)about 9-15 times. It is presumed that the EU PM_{10} limit value concentration (50 μg/m^3 daily mean and 40 μg/m^3 annual mean) could have also been exceeded, since TSP/PM_{10} ratio is 1.35[6]. Furthermore, CO concentrations were exceeded almost every month for Rustavi, Kutaisi and Tbilisi Tsreteli Avenue site, located on the road side. Average annual concentrations of CO were higher than MAC for all these cities. Ozone concentration measured only at 1 manual sampling site and 1 automatic station in Tbilisi was below or equal to Georgian MAC (30μg/m^3) for all months, except for August through October 2013 exceeding it about 1.8-3.1-fold at Kvinitadze manual sampling monitoring site. Furthermore, lead concentrations measured only at Tbilisi Kvinitadze site from August 2013 through February 2014 was far below Georgian MAC (0.3 μg/m^3) as well as this, its annual mean average concentration was below EU annual mean limit value (0.5 μg/m^3). Manganese

[6] Source: A report on Guidance to Member States on PM10 monitoring and intercomparisons with the reference method. EC working group on particulate matter, 2002

concentration in the form of MnO_2 measured only in Zestaponi regularly exceeded Georgian MAC (1.0µg/m^3).

Regarding air quality trend for last 5 years (2008-2012), they were more or less similar to 2013 annual average concentrations data, showing systematic non-compliance with NO_2, SO_2, dust almost in all cities and MnO_2, measured in Zestaponi. Annual CO concentrations also are exceeded for Batumi in 2010, for Rustavi in 2011-2012, for Tbilisi in 2008-2010 and 2011 and for Kutaisi in 2010-2012. Annual average concentration of Ozone exceeded existing MAC only in 2011.

Table 4 Monthly Air Pollutant Concentrations between Feb 2013 to Feb 2014 inGeorgianUrban Centres

Date		Monthly Average Concentration (μg/m3)												
		Feb-13	Mar-13	Mar-13	Apr-13	May-13	Jun-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14
Pollutant		**Batumi**												
Dust		470	400	590	560	500	400	480	450	440	390	380	380	360
SO_2		160	120	130	140	120	160	130	130	130	150	140	140	120
CO		2,250	2,300	2,300	3,200	3,820	4,300	3,900	0.00	1,900	1,980	1,900	1,800	1,500
NO_2		139	150	200	160	180	160	160	140	130	140	94	110	130
		Zestaponi												
Dust		440	400	510	400	450	400	400	400	400	400	390	390	400
SO_2		119	120	130	130	130	130	130	130	129	130	120	120	130
CO		1,200	1,200	1,300	1,100	1,400	1,400	1,500	1,400	1,500	1,500	1,400	1,300	1,500
NO_2		45	47	46	46	50	40	49	46	50	49	40	48	48
MnO_2		5.00	4.00	6.90	4.30	6.80	5.00	4.00	5.00	4.60	3.90	4.30	4.30	5.10
		Rustavi												
CO		3,650	3,410	3,400	3,500	3,400	3,600	3,600	3,200	3,900	3,280	3,500	3,300	2,700
NO_2		101	96	110	100	110	120	120	110	130	110	120	124	120
		Kutaisi												
Dust		900	800	850	840	760	600	700	600	770	800	800	700	700
SO_2		189	180	190	200	160	180	180	180	180	180	157	170	180
CO		3,400	3,100	3,100	4,100	4,100	3,200	3,300	2,700	2,980	3,700	2,100	2,400	3,800
NO_2		120	126	130	130	120	110	120	120	120	127	120	120	120
Nitrogen Oxide		110	110	110	120	110	99	117	110	100	108	110	110	100.
		Tbilisi												
Dust	Kvinitadze St.	680	560	580	720	600	480	660	510	800	870	870	980	1.020

SO_2	Kvinitadze St.	110	113	110	130	130	120	130	120	130	119	100	110	120
	Kvinitadze St.	4,300	4,000	2,500	2,800	2,200	1,800	1,900	1,800	2,600	6,100	6,400	3,600	4,300
	Moscow Ave.	2,900	2,600	2,800	2,800	2,700	2,580	2,600	2,500	2,300	2,200	2,300	2,400	1,800
CO	Tsereteli Ave	3,800	6,020	5,300	4,900	4,800	4,200	3,400	4,400	4,400	4,800	7,700	4,100	0.00
NO_2	Kvinitadze St.	75	80	119	139	140	120	99	110	89	90	70	73	87
	Moscow Ave.	103	88	90	94	90	80	78	80	80	80	89	90	110
O_3	Kvinitadze St.	8.00	14	12	8.00	15	25	54	56	93	10	12	6.20	12.50
Lead	Kvinitadze St.							0.120	0.110	0.140	0.110	0.120	0.120	0.600

Table 4 Georgian Maximum Allowable Concentrations

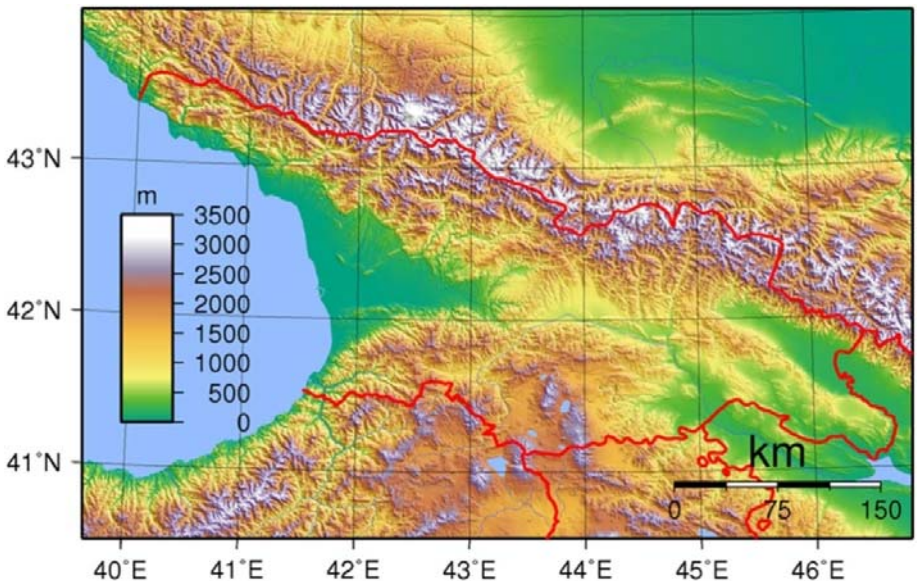
	MACs/ µg/m^3	
Pollutant	**One time maximum (averaging time: 20-30 min.)**	**Daily average (averaging time: 24 hours)**
Dust	150.0	50.0
SO_2	500.0	50.0
CO	5,000	3,000
NO_2	200.0	40.0
MnO_2	10.0	1.0
Nitrogen Oxide	400.0	60.0
O_3	160.0	30.0
Lead	1.0	0.3

6. CLIMATIC AND METEOROLOGICAL CONDITIONS IN GEORGIA

6.1 General Description

Georgia is a mountainous country, with a total area of 69,700 km^{2}and a population sizeof about 4.33 million. It is located in the South Caucasus region, on the eastern coast of the Black Sea forming the western border of the country. The Greater Caucasus, the main ridge of the Caucasus Mountains, forms the northern border and the Lesser Caucasus Mountains occupy the southern part of the country. To the east of the Liakhvi range a high Kartli plateau extends along the Kura River to the border with Azerbaijan.[7]

Figure 2. Topography of Georgia[8]

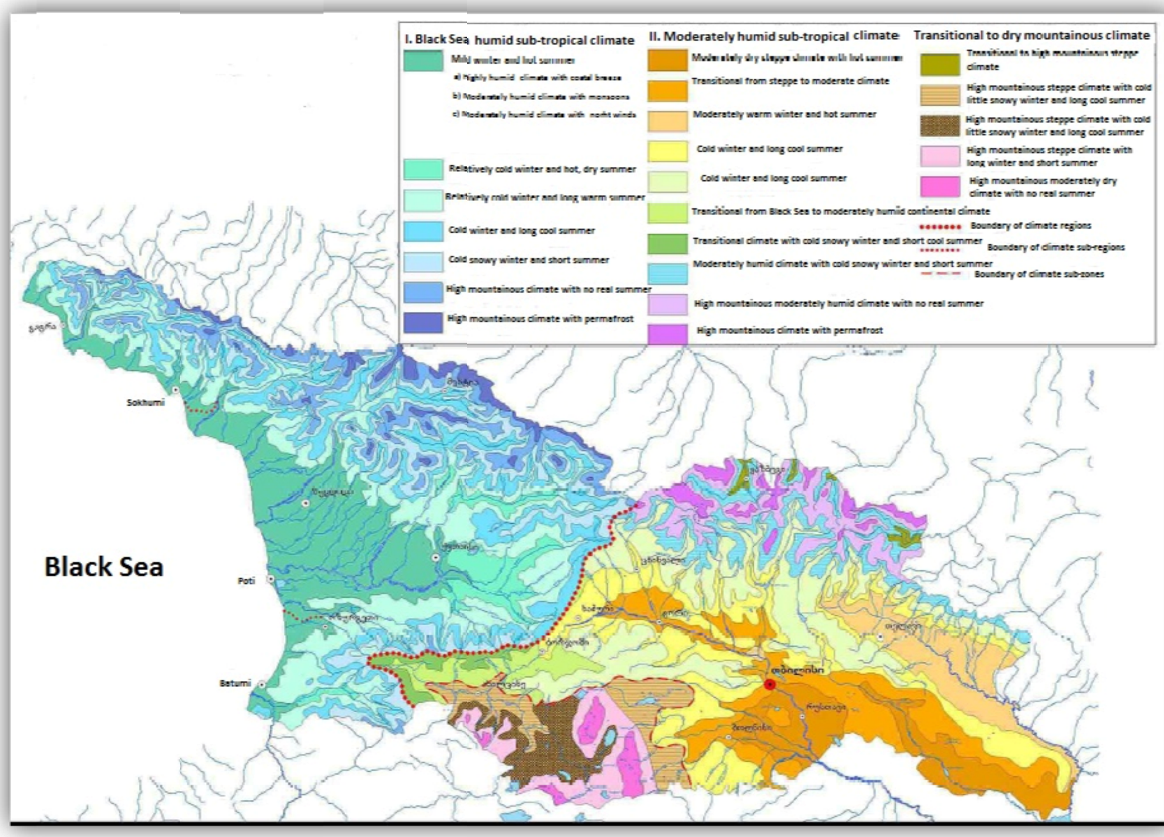


The country is known for its complex terrain and climatic diversity, ranging from humid sub-tropical to moderately humid sub-tropical to continental, arid and semi-arid climatic belts.More specifically, the country is located in sub-tropical climate region, with two distinct weather/air circulation zones: Black Sea humid sub-tropical and moderately humid sub-tropical and, one transitional to dry mountainoussub-zone. Within these larger climate zones almost every climatic belt is represented except for savannahs and tropical forests. To the North, the range of the Great Caucasus protects the country from the direct penetration of cold air. The circulation of these air masses mainly determines the precipitation regime all over the territory of Georgia.

[7] Source: ENVIRONMENTAL ASSESSMENT: INTEGRATED NATURAL RESOURCES MANAGEMENT IN WATERSHEDS OF GEORGIA(INRMW-GEORGIA), USAID/GLOWS program: Integrated Natural Resources Management in Watersheds of Georgia. http://www.globalwaters.net/wp-content/uploads/2012/12/INRMWPEAfinal.pdf

[8] Source: Technical Report 2. Rapid Assessment of the Rioni and Alazani-Iori River Basins of Georgia June, 2011. USAID/GLOWS Integrated Natural Resources Management in Watersheds (INRMW) of Georgia Program.http://www.globalwaters.net/wp-content/uploads/2012/12/Annex-1-to-Tech-Rep-2.-Geographicfeatures.pdf

Figure 3. Climate Map of Georgia[9]



The climate in Western Georgia is highly diverse, altering in certain areas very sharply from humid subtropical to permafrost. It is determined by the Black Sea coast to the West, and by three mountain ranges (the Great Caucasus, the Likhi and the Meskheti), in addition to the surrounding Kolkheti lowland (wetland) in the very centre. The Black Sea coastal zone has a humid subtropical climate. The average annual temperature there is 14-15^{0}C, with extremes ranging from +45^{0}C to -15^{0}C, and annual amounts of precipitation vary between 1,500 mm and 2,500 mm. The Black Sea influences the climate of West Georgia, resulting in mild winters, hot summers and abundant precipitation. Here in the mountainous and high mountainous areas, the annual air temperature ranges from 6-10^{0}C to 2-4^{0}C with an absolute minimum between -30^{0}C and -35^{0}C, and annual amounts of precipitation range between 1,200-1,600 mm and 2,000 mm.

In East Georgia the climate is also complex: the basin of the River Mtkvari (Kura) crosses the central plain. To the South of the river stretches the volcanic Javakheti Highland,with the Samsari Range (its highest peak at 3,301m above sea level) at its centre. Kakheti makes up the extreme eastern region, which borders the southern branch of the Great Caucasus range from the North. The climate in the plains of East Georgia is dry: in the lowlands, it is a dry subtropical climate, and in mountainous areas it is alpine. The average annual temperature is 11-13^{0}C in the plains, and 2-7^{0}C in the mountains. The absolute minima are -25^{0}C and -36^{0}C respectively. The absolute maximum reaches +42^{0}C and the absolute minimum falls to -42^{0}C in the high mountains (the slopes of Mount Kazbegi). The annual amounts of precipitation vary in the range of 400-600 mm in the plains, and 800-1,200 mm in the mountains.[10]

[9] Source: Technical Report 2. Rapid Assessment of the Rioni and Alazani-Iori River Basins of Georgia June, 2011. USAID/GLOWS Integrated Natural Resources Management in Watersheds (INRMW) of Georgia Program. http://www.globalwaters.net/wp-content/uploads/2012/12/Annex-1-to-Tech-Rep-2.-Geographicfeatures.pdf

[10] Source: Georgia's Second National Communication to the UNFCCC. Tbilisi 2009. http://unfccc.int/resource/docs/natc/geonc2.pdf

Thus, due to its proximity to the Black Sea, the annual total of precipitation in western Georgia is higher(950 – 4,500 mm) than in Eastern Georgia (400 – 1,800 mm). The Black Sea zone (Batumi – 2,318 mm; Poti– 1,639 mm; Sokhumi – 1,460 mm) and the Caucasus and the Ajara-Trialeti Ranges (Gagra ridge 1,644 m above sea level (asl) – 1,737 mm; Gudauri – 2,194 m asl – 1,371 mm; Bakhmaro – 1,926 masl– 1,406 mm) are distinguishable by their abundance of precipitation. In general, the annual total precipitation increases with elevation. However, this trend is interrupted in some locations (upper Svanetidepression, Javakheti Plateau, Tori and Akhaltsikhedepressions) due to the influence of certain orographic conditions. Within the country, 55-75% of all precipitation occurs in the warm season (April to October).[11] More specifically, in West Georgia precipitation maximums are recorded in fall-winter and minimums in spring-summer, while in East Georgia the maximum precipitations occur in spring-beginning of summer and minimums – in winter.

Figure 4.AverageAnnualTemperature of Georgia

[11] Source: Atlas of Natural Hazards, Chapter 2, CENN, http://drm.cenn.org/paper_atlas/RA-part-2.pdf

Figure 5.Temperature in June[12]

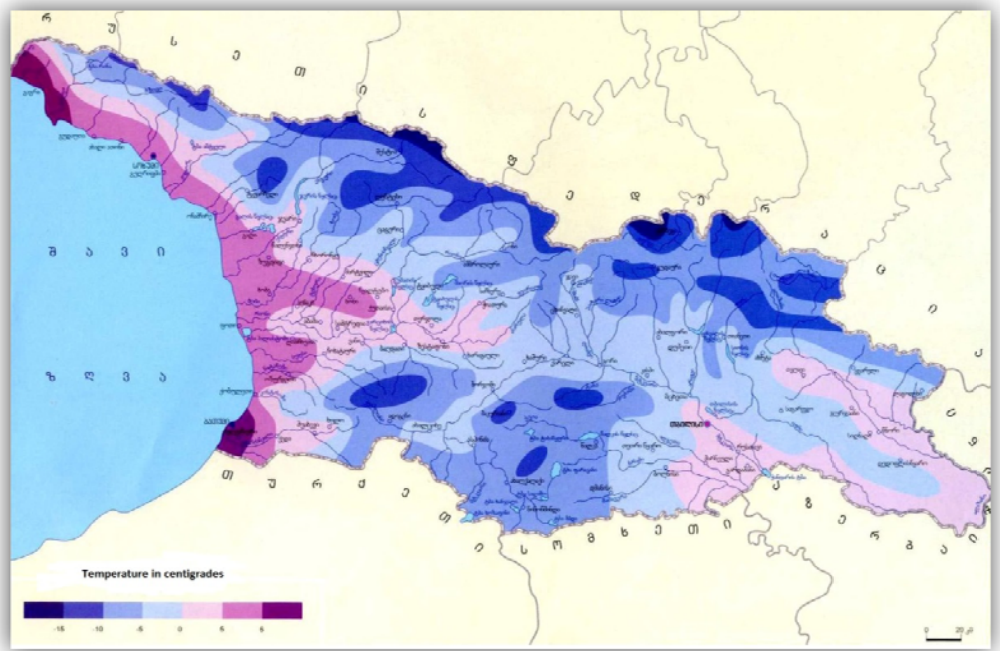
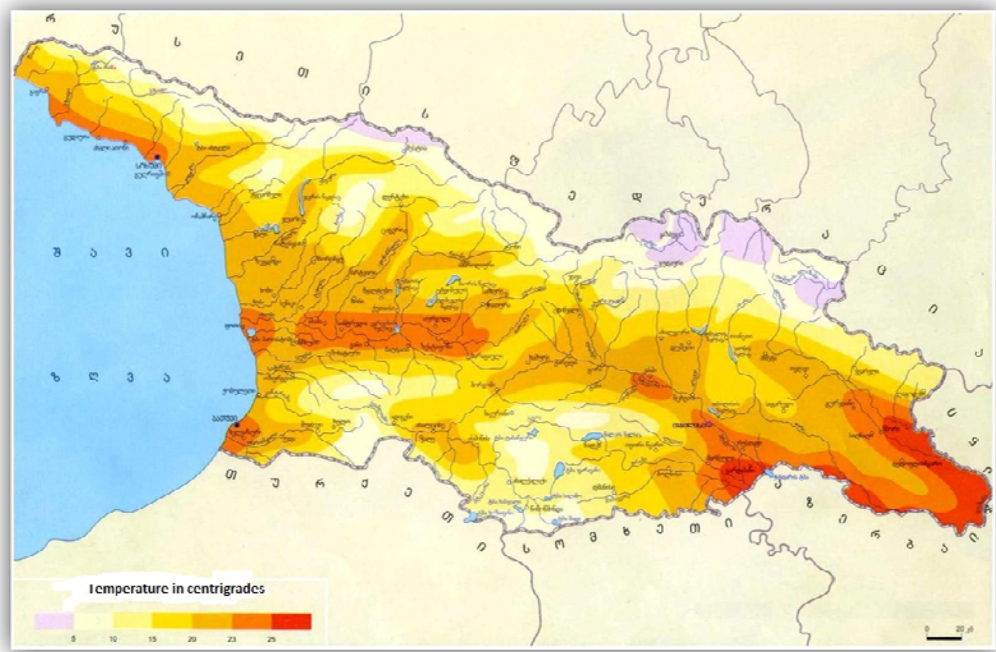


Figure 6. Temperature in January



[12] Source for figures 3, 4, and 5: Technical Report 2. Rapid Assessment of the Rioni and Alazani-Iori River Basins of Georgia June, 2011. USAID/GLOWS Integrated Natural Resources Management in Watersheds (INRMW) of Georgia Program.http://www.globalwaters.net/wp-content/uploads/2012/12/Annex-1-to-Tech-Rep-2.-Geographicfeatures.pdf

Figure 7. Annual Sums of Precipitations

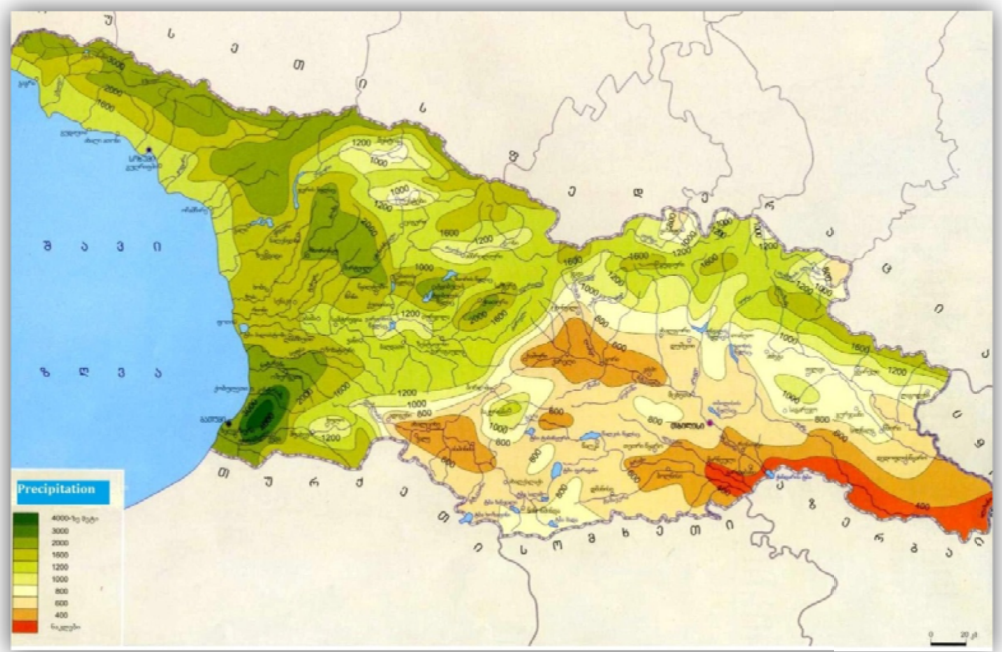
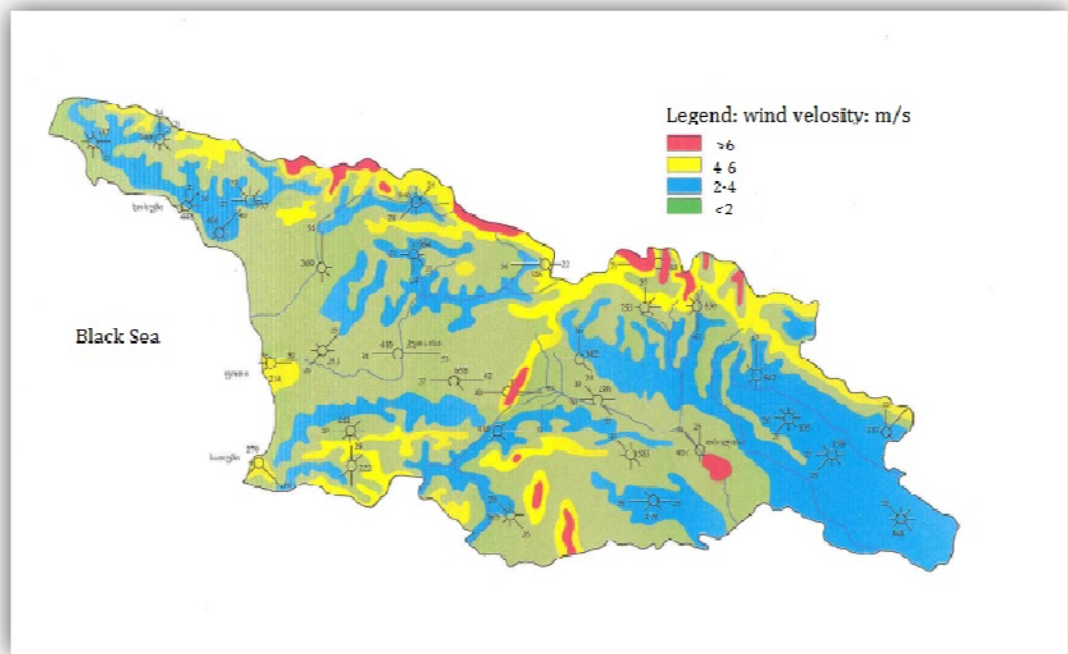


Figure 8. Average Annual Wind Velocity



6.2 Description of Climate per Physico-geographic Regions

The climate in Georgia varies significantly within different physico-geographic regions divided based on orographic features. There regions are: A. Greater Caucasus divided into Western, Central and Eastern Caucasus; B. Humid sub-tropical Kolkheti region divided into Imereti upland (plateau) and, Kolkheti hills, foothills and lowland; C. Kartlian (Iberian) region divided into Shida (inner) Kartli low-mountain, hilly, foothill and lowland sub-region, Kvemo (Lower) Kartli foothill-plain sub-region, Saguramo-Gombori middle-mountain sub-region, Inner Kakheti hilly-plain (Alazani valley) sub-region and IoriPlateau; D. Lesser Caucasus divided into Meskheti range and Trialeti range sub-regions; E. Meskhet-Javakheti volcanic region divided into Meskheti depression (plain)and Javakheti plateau.

In Western Greater Caucasus sub-region, where mountainous Abkhazia, Racha-Lechkhumi and Lower Svaneti region and, Upper Svaneti part of Samegrelo-Upper Svaneti region are located, predominantly Black Sea sub-tropical humid climate is met. The region is abundant with solar radiation. It is highly influenced by the Black Sea and western humid winds. The climate here is characterized with altitudalzonality. In lower parts, annual average temperature is 5-12 °C and decreases gradually with elevation. At the altitude of 2,500 m above sea level (a.s.l) and above it becomes negative.At the altitude of 700-800 m a.s.l. January average temperature is 1-2°C; in high mountainous regions it reaches minus 15°C. Absolute minimum varies within minus 25°C-40°C. July-August average temperature is 6-22°C and, absolute maximum 20-42°C. Atmospheric precipitations vary within the range of 1800-3500 mm; exceptions are closed depressions, like Svaneti and Racha-Lechkhumi, where this parameter varies within 900-1200 mm. Windward slopes receive greater precipitation than opposite slopes. The region is characterized with high cloudiness and humidity;humidification ratio is 1.5-3.5 and more. Snow cover makes up 3-4 m. Winds, hailstorms and thunderstorms occur frequently. Tkvarcheli and Tkibuli municipalities are located at the border of Kolkheti humid sea and West Caucasus climate regions therefore, are influenced by both.

Central Caucasus, where Kazbegi municipality, parts of Java, Akhmeta (Omalo) and Dusheti (Pasanauri) municipalities are located is distinguished with moderately humid to high-mountain humid permafrost climate. Here vertical zonality isnoticeable. At the altitude of 1,740 m a.s.l. the climate is moderately humid with cold dry winter and long cool summer. Annual average temperature is 4.9^{o}C, January temperature – minus 5.2^{o}C, July temperature 0 14.4oC and absolute minimum temperature – minus 34^{o}C. Annual average precipitation makes up about 800 mm. At the altitude of 1970 m a.s.l. average annual temperature is 3.5^{o}C and annual sums of precipitation – 1,160 mm. Maximum amount of precipitation is recorded in May (147 mm) and minimum amount (50 mm) – in May.At the altitude of 2000 m a.s.l.and above the climate is withoutsummer. At the altitude of 3,650 m annual average temperature is minus 6.1^{o}C, January temperature – minus 15^{o}C, absolute minimum – minus 42^{o}C and snow cover duration – 277 days.

In East Caucasus, where mountainous parts of Kvareli and Lagodekhi municipalities are located the climate is transitional from dry continental to the humid sub-tropical climate. Here vertical climate zonality isnoticeable. In the lower parts annual average temperature is 8-10°C, at 3500 m a.s.l- minus 6°C. The coldest months are January and February with monthly averages of minus 3°C and minus 15°C respectively, absolute minimums make up minus 26°C-42°C; the warmest months are July and August with monthly averages ranging within 2-18°C and monthly maximums ranging within 16-40°C. Precipitations increase with altitude and vary within 800-1,800 mm. Claude cover is moderate (50-60%), annual relative humidity – 65-75%. Snow over makes up 25-50 sm on average. Winds are mostly blowing towards river gorges and generally, north winds prevail (28%), followed by north-east winds (16%) and south (15%) winds. In the upper parts of the region west winds dominate.

On Imereti upland, where Sachkhere and Chiatura municipalities and part of Kharagauli municipality are located the climate is humid with moderately cold winter and hot relatively dry summer. Annual mean temperature at the altitude of up to 400-700 m is +10-140C, with +1.5-4.00C January and +22-240C July temperatures; Extreme temperatures are recorded at -16, -200C, and at +39-400C. Annual sum of precipitation is 1,100-1,200 mm with maximum precipitation recorded in fall and winter seasons. At higher altitudes temperature declines as per vertical zoning, while precipitation increases. The winter is characterized by north-east winds and the summer – by south-west winds. North-east winds are dominating ones in the wind rose.

In the middle reach of the Rioni river basins, where the city of Kutaisi is located the climate is transitional from that of Imereti Upland and the Kolkheti Lowland (plain). The mean temperature for winter is +5.2^{0}C, with absolute minimum reaching -17^{0}C, the mean temperature for the warmest month of the summer is +23.6^{0}C, with absolute maximum reaching +42-43^{0}C. The wind rose distribution is as follows: north wind – 1%; north-east wind – 3%; east wind – 53%, south-east wind – 5%, south wind – 1%; south-west – 3%, west wind – 35%, north-west wind – 2%. Still weather conditions have 27% occurrence. Strong east winds (55%) occur in fall-winter seasons. But, mostly east winds (48%) prevail in spring-summer. Annual sum of precipitation is 1,586mm, with maximum precipitation in January-February and minimum precipitation in May and September (92-95 mm). Relative humidity in the coldest month is 60% and in the hottest month – 50%. Hail and thunderstorm occur in warm seasons.[13]

Downstream of Kutaisi the climate is mild humid sub-tropical, with moderately cold winter and relatively dry hot summer. Annual mean temperature is + 13.9 – 14.10^{0}C, with +3.70 – 4.30^{0}C January temperature and +23.6 – 23.9^{0}C August temperature. Averaged minimum temperature never goes below -0.1^{0}C and averaged maximum temperature never exceeds +30.2^{0}C. Absolute maximum is +42^{0}C and absolute minimum -20^{0}C. Annual sum of precipitation is 1,190 mm, with maximum values recorded in winter and minimum values recorded I summer. In low-mountainous and up hills the temperate is slightly lower and the precipitation – higher. East and West winds are dominating there. Sometimes, the Black Sea breeze reaches the region.

Kolkheti plain, where the large portion of Imereti lowlands (Samtredia, Tskaltubo municipalities), Samegrelolowlands and the entire Black sea coast (Coastal Guria, Adjara, Poti, Coastal Abkhazia) are located the climate is extremely humid sub-tropical and is highly influenced by the Black Sea. Winter is mild and summer is also relatively cool. This type of climate is formed as a result of interaction between wet air masses intruding from the Black Sea and the southern slopes of the Greater Caucasus Range, and the western slopes of the Meskheti Range. The air flow regime is greatly affected by local circulation, resulting from the

[13] Source: Sakaeronagigatsia, http://airnav.ge/index.php?page=ms&fullstory=41; Technical Report 2. Rapid Assessment of the Rioni and Alazani-Iori River Basins of Georgia June, 2011. USAID/GLOWS Integrated Natural Resources Management in Watersheds (INRMW) of Georgia Program, http://www.globalwaters.net/wp-content/uploads/2012/12/Technical-Report-2-Rioni-Alazani-Iori.pdf; ka.wikipedia.org/wiki/საქართველოს_კლიმატი

uneven heating of sea and land surfaces, manifested in breezes, monsoons and mountain-valley winds.

According to multi-year hydrometeorological observations, until 1990s the mean annual air temperature in the coastal area varied in the range of +14.4-14.5^{0}C and annual sums of precipitation from 1,400 mm to 2,600 mm (Batumi). In the last half-century, hydrometeorological parameters of the Black Sea coastal zone underwent certain changes in relation to the global climate changes. During the past century till the beginning of the 1990s, the air temperature here decreased by 0.2-0.3^{0}C though, for the last 16 years it increased by 0.2^{0}C. Compared to the 1960s, the precipitation in Poti for the last 15-20 years has grown by 13%, but in Batumi it has declined by 5%. Quite similar to the air temperature, the sea surface temperature had decreased by 1.0^{0}C, throughout 1924-1996. However, in 1990-2006 it had grown by 1.3^{0}C, as a result of which the cooling of the sea surface at present equals 0.8^{0}C, compared to the 1924 value. Precipitations mostly occur in winter and fall. In winter snow cover is unstable. In winter east winds prevail and in summer – west winds. Breezes occur almost permanently. Due to the influence of the sea and west winds, cloudiness and humidity is high, reaching 70-80% in relative terms. Hail and thunderstorms happen all year around.

Shida (Inner) Kartli low mountain, foothill and lowland sub-region where parts of Khashuri, Mtskheta and Dusheti municipalities, entire Gori and Kaspi municipalities and significant part of Tskhinvali region, including the city of Tskhinvali are located is characterized with dry sub-tropical climate influenced by high mountain ranges. Winter is cold here compared with other areas of Georgian located at similar altitudes. Average annual temperature is 9-11^{0}C; January temperature – 1-4^{0}C; August temperature – 20.4-22.3^{0}C. Absolute minimum is 26-31^{0}C and maximum - 40^{0}C. Here west and east winds prevail. The first is cool and humid and the second, humid and cold in winter and hot in summer. Annual sums of precipitation make up 500-800mm. Droughts occur frequently. Snow cover does not pertain longer periods. Thunderstorms occur 30-45 days a year and hails 1-2 days a year.

KvemoKartli foothill and lowlandphysic-geographic region,where entire KvemoKartli region, part of Sagarejo municipality and the capital Tbilisi are located has dry subtropical climate and transitional foothill climate of Lower Kartli Plain. The transitional climate where large portion of KvemoKartli, including the city of Rustavi is located is characterized with moderately cold winter, hot summer and moderate humidity decreasing from west to east. Prevailing winds in the region, including Rustavi and Tbilisi are north-west and south-east.

KvemoKartli plain is open from the east therefore, air masses intrude easily from this side; west winds blowing from the Kura river gorge are also frequent. The climate is influenced by convections occurring in the south of the South Caucasus that brings lots of rains, thunderstorms and hails. The region is characterized with high solar radiation (2500 hours annually). Annual average temperature is 12^{0}C; January temperature – 0.2^{0}C; July-August temperature – 23-25^{0}C. Absolute minimum is minus 20-25^{0}C and absolute maximum 40-41^{0}C. Annual sums of precipitation make up 400-600 mm. exceptionally dry and arid is the south part. Droughts occur frequently. Snow cover does not pertain longer periods. Thunderstorms occur 35-50 days a year and hails 1-2 days a year.

Inner Kakheti hilly-lowland sub-region where significant parts of Akhmeta, Telavi, Kvareli, Lagodekhi, Gurjaani, Signagi and Dedoplistskaro municipalities are located is well-protected from intrusion of air masses from west and north. An intrusion of air masses is only possible from the south-east and therefore, the area is considered one of the driest regions of Georgia. However, it is characterized by climate conditions varying from sub-tropical continental to humid. The Northwest part of the plain has a moderate humid climate with relatively cold winters and hot summers and the east part – a relatively warm steppe climate, with hot and dry summers and moderate cold winters. Thus, the more humid climate is in the left part of the plain due to the nearby location of the Caucasus massif. The average annual precipitation in the area varies from 800-1300 mm, with the highest values reported for the months of May (14-16% of the annual total) and September (10% of the annual total). January is the driest month (only 3-4% of the total annual). Summer months are very dry. The average annual air temperature is between +9°C and +14°C. The minimum temperature rarely drops below minus 23°C and the maximum temperature does not exceed plus 39°C. The average temperature of the coldest month is within the range of 0°C to +5°C and that of the hottest month is within the range of +22°C to +27°C. West and east winds dominate in Alazani valleys. Stable snow cover is not a frequent phenomenon and reaches 5-15 sm, maximum height is 75 sm.Thunderstorms occur 30-60 days a year and hails 1-2 days a year. Hails are characterized with large size of particles that frequently poses significant damage to the region.

Saguramo-Gombori middle-mountain area, where parts of Telavi, Gurjaani, Signagi, Dedoplistskaro and Sagarejo municipalities and entire Tianeti municipality are located is characterized with moderately humid sub-tropical climate, with cold winter and long cool summer.

In the upper parts of the region, where upstream of the Iori river basin is located the climate is moderately humid, with cold winters and long warm summers at altitude of up to 1,900m above sea level. At higher altitudes summer becomes shorter and at 2,400-2,500 m and above the climate is high mountainous moderate humid. Annual mean air temperature in lower parts is 8.5°C and at the altitude of 2,400m it drops to 0°C. January mean temperature in lower parts is -2°C and July mean temperature – +19°C; In high mountainous areas January mean temperature drops at -10°C and below and July temperature does not exceed 8-10°C. Absolute minimum is within the range of -28-40°C and absolute maximum – within the +20-22°C and +35-36°C. Annual sum of atmospheric precipitation at lower parts of Tianeti municipality is 620mm and at highlands – 1,300-1400mm. Snow cover in winter periods is characteristic of entire Tianeti region with from 20sm (in Sioni) to 2m snow cover. Downward the climate is getting drier with cold winters and hot dry summers. Average annual temperature is +10-11^{0}C, January temperature – minus 1-3^{0}C, July-August temperature – plus 22-24^{0}C. Average annual atmospheric precipitation is 400-500mm. Snow cover is rarely formed. Throughout the year wet winds are dominant. Relative humidity is 75-80%. Foggy conditions occur frequently. Warm periods are characterized with thunderstorms and hail. Winds blowing from river gorges are frequently observed.

Iori Plateau sub-region where lower reaches of the Iori river basin (parts of Sagarejo, Gurjaani, Signagi, Dedoplistskaro municipalities) is located has dry continental climate with cold winters and hot, dry summers. Droughts are frequent phenomena. Average annual temperature is 10-11^{0}C, January temperature – 1-3^{0}C, July-August temperature – 22-24^{0}C. Absolute minimum is minus 24-32^{0}C and absolute maximum - 40^{0}C. West winds are prevalent, which are extremely strong in winter. Thunderstorms happen 20—40 days a year and hails - 1-3 days a year.

Meskheti sub-region of the Lesser Caucasus region, where mountainous Adjara and Guria, and part of Kahragauli municipality are located is directed to the west and is influenced by the Black Sea. Therefore, the area is characterized with humid climate. Annual average temperature is 2-120C; January temperature at the altitude up to 1100 m a.s.l - 00C and at higher altitudes – minus 8-100C. The warmest month is august with 10-200C average temperature. On the slopes directed towards the sea, west and south-west wet winds dominate all year around. Therefore, this region is characterized with high amounts of precipitations. The middle reach of the Adjaristskali watershed is relatively dry, since it is protected by high ridges from the west. In the region, snow may fall in November; at the altitude of 1,400 m it may stay 1-3 day, while at the altitude of 2,000 m a.s.l6-7 months. Maximum height of the snow cover is 4-5 m. Thunderstorms occur all over the year, but is more frequent during warm seasons.

The sub-region of the Trialeti ridge, where Borjomi municipality and parts of KvemoKartli region (parts of the Bolnisi and Dmanisi municipalities) are located is more or less protected by Meskheti ridge from the west though, influence of west air masses is notable in Borjomi-Bakuriani surroundings. On the east slopes of the Trialeti ridge, air masses flowing from the east, impact the local climate. On the northern and southern slopes air masses flow in parallel to the ridge and the climate here is continental with low amount of precipitations. Relatively mild warm winter is characteristic to Borjomi gorge.

Average January temperature in the region is minus 2-110C, while the absolute minimum may go down to minus 400C. Average monthly temperature of the warmest month is 9-200C, absolute maximum - 370C. The region is distinguished with moderate cloudiness, long sunny periods and high level of snow cover.

Meskheti depression where almost entire Akhaltsikhe municipality is located is characterized with dry continental climate. Winter is cold with January temperature varying from minus 2.50C to 9 0C; absolute minimum is minus 30-380C. Summer is moderately hot, with July-August average temperature making up 16-210C and maximum temperature - 390C. Annual sums of precipitation are 500-700 mm. The summer is droughty. Snow falls from October and its cover becomes stable in December until the end of March. Thunderstorms and hails are frequent phenomena.

On the JavakhetiPlateu, where significant part of Samtskhe-Javakheti region (Akhalkalaki, Ninotsminda, Aspindza, Tsalka municipalities and part of Dmanisi municipality) continental climate with extremely cold winter is prevailing. In some parts transitional from moderately humid to dry mountainous climate is met. Annual average temperature is 4-6 0C; January temperature – minus 5-100C; July temperature – 15-160C; absolute minimum – minus 34-410C and; absolute maximum – plus 30-350C. Annual sums of precipitation are 600-70 mm. Freezing sunny days are frequently observed and the winter is exceptionally dry. Snow cover occurs in December and lasts until the end of March. Thunderstorms and hails are frequent phenomena.

6.3 Meteorological Stations and Data Sets available in Georgia

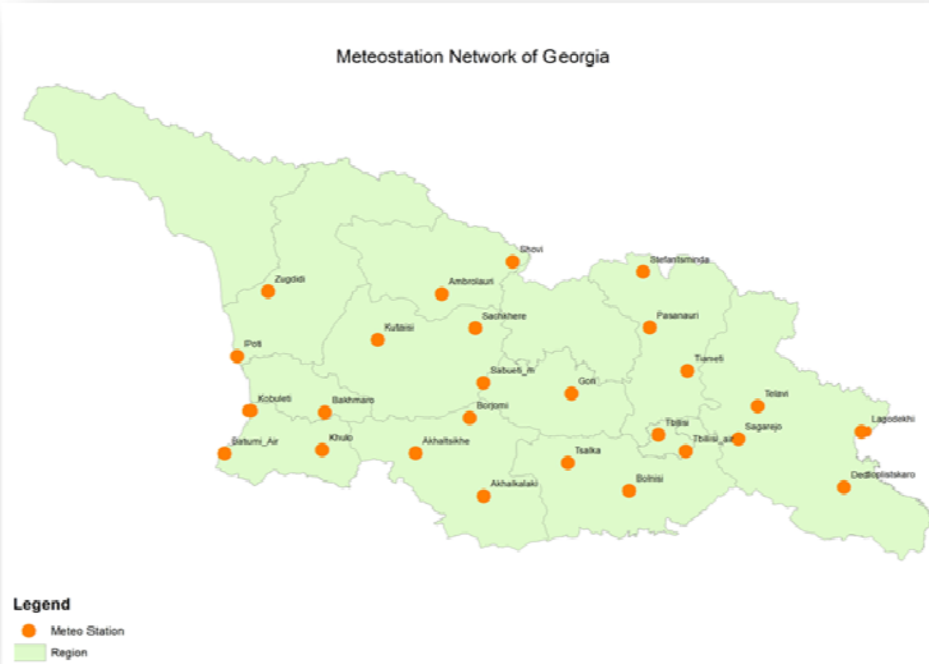
In Georgia the Department of Hydrmeteorology(under the National Environment Agency, a quasi-independent entity of the Ministry of Environment and Natural Resources Protection) provides all interested parties with the following chargeable data and services[14]:

- Forecasted data
- Short-term weather forecasts (for the territory of Georgia in accordance with physical-geographical regions and points);
- Middle-term weather forecasts (for the territory of Georgia in accordance with physical-geographical regions and points);
- Monthly weather forecasts for the territory of Georgia (for physical-geographic regions);
- Regime (Historical) Data
- Meteorological information of the current day, received from observational network (air temperature, atmospheric pressure, wind direction and speed, atmospheric processes);
- Metadata on meteorological stations and posts;
- List of the elements observed on meteorological stations and posts:
  a. Air temperature ^{0}C (average, maximal, minimal);
  b. Temperature of the soil surface ^{0}C (average, maximal, minimal);
  c. Air humidity (partial pressure of water steam, saturation deficit, dew point, relative humidity);
  d. Hourly information on air temperature and relative humidity received from self-recorder;
  e. Atmospheric pressure in hectopascals (on the station level, sea level and barial tendency);
  f. Precipitation amount (in mm);
  g. Wind (speed in m/sec, direction);
  h. Weather on term and between the terms;
  i. Cloudiness (shape, number, height);
  j. Visibility (in km);
  k. Conditions of soil surface (description).

Daily, 7-day and 10 day weather forecasts are available online at NEA's site http://meteo.gov.ge/. Currently, there are 26 meteorological stations in Georgia.Measurements are made every three hours at 24:00, 03:00 am, 06:00 am, 09:00 am, 12:00, 15:00, 18:00 and 21:00. Though, complete set of recent hourly and daily data on wind direction, wind speed, temperature and cloudiness are hardly available for many stations. For instance, under this assignment for modelling of urban air quality of the cities of Batumi, Rustavi, Zestaponi, Kutaisi and Poti we were able to get a complete set of 3-hour daily meteorological data only for the period of 2006.

[14] Source: www.meteo.gov.ge

Figure 9. Operating Meteorological Stations in Georgia

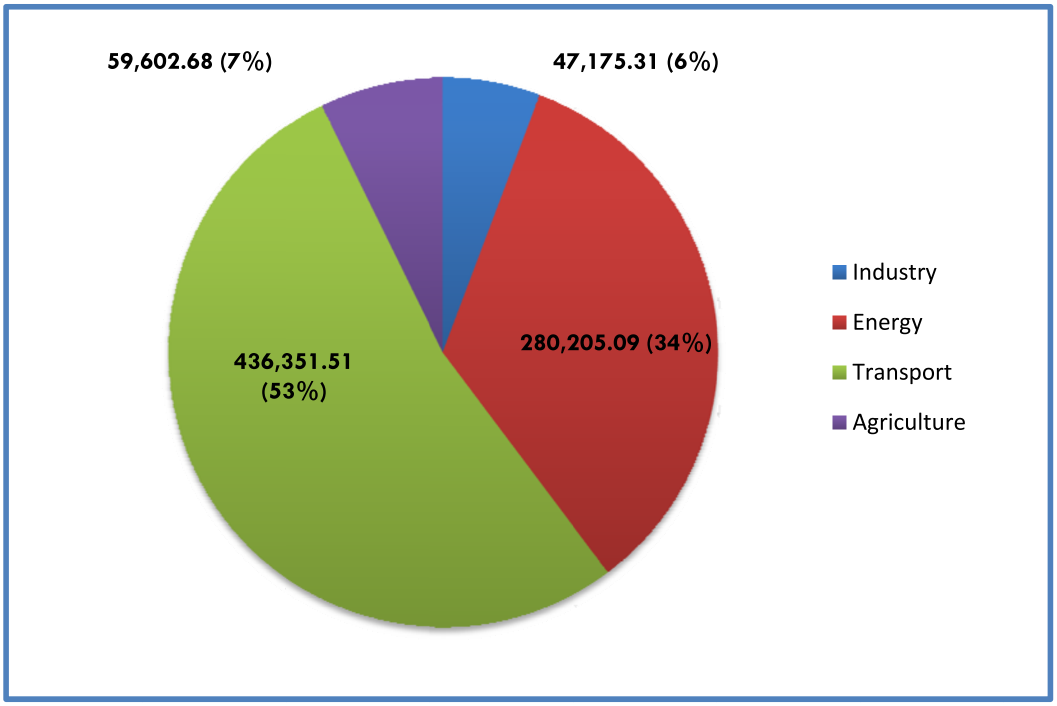


7. EMISSION INVENTORY FOR GEORGIA

7.1 GROSS EMISSIONS FROM DIFFERENT SECTORS

Based on the latest official emission inventory data (2012) compiled by the MoENRP based on CORINAIR emission inventory methodology, transport is the largest contributor to gross national emissions (53%).

Figure 10.Percentage share and tons of emission for various sectors in 2012 gross emissions[15]



In terms of sector contribution to emissions of individual pollutants, in 2012 the transport sector was the largest contributor to total CO (80%), NO_x (63%) and O_3 precursor gases (46%) emissions followed by the energy sector, the energy sector – the largest contributor to total SO_2 (54%) and VOCs (58%) emissions followed by the transport sector, and the industry sector – the largest contributor to total TSP (62%) emissions followed by the transport sector. Agriculture was the single gross polluter of NH_3.

[15] Sources for figures 6-13: Air Protection Service of the MoENRP

Figure 11. 2012 emissions of individual pollutants by different sectors, tons

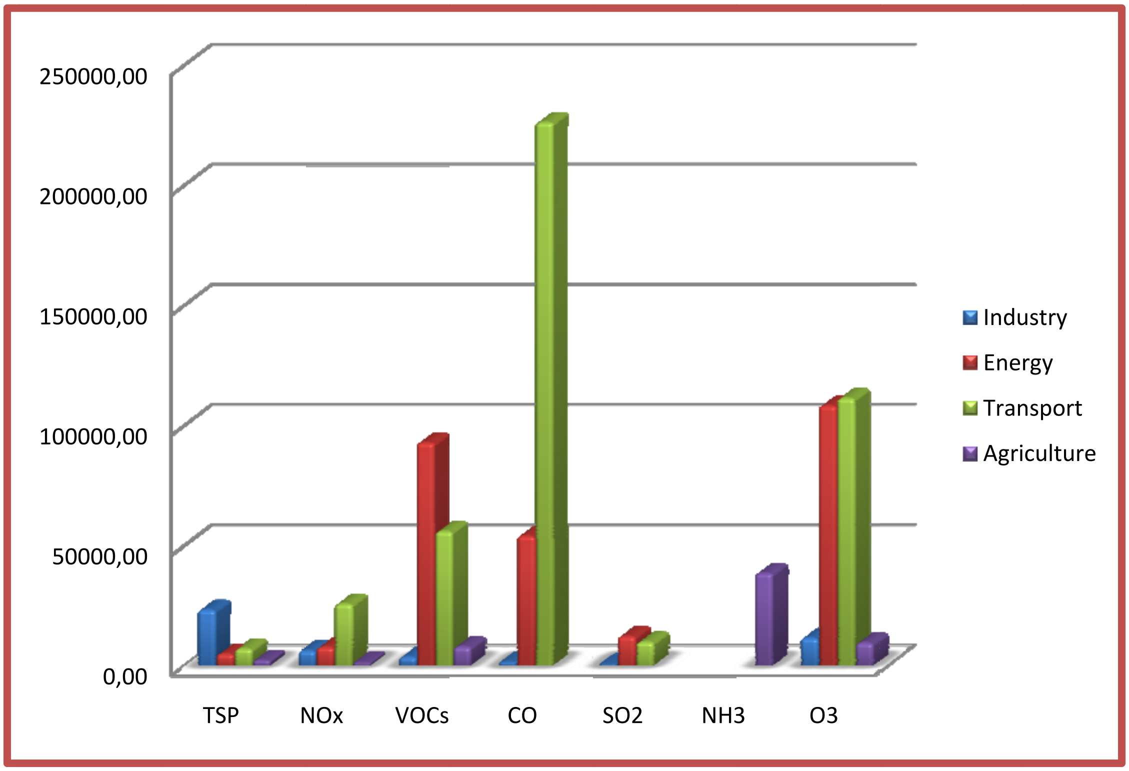
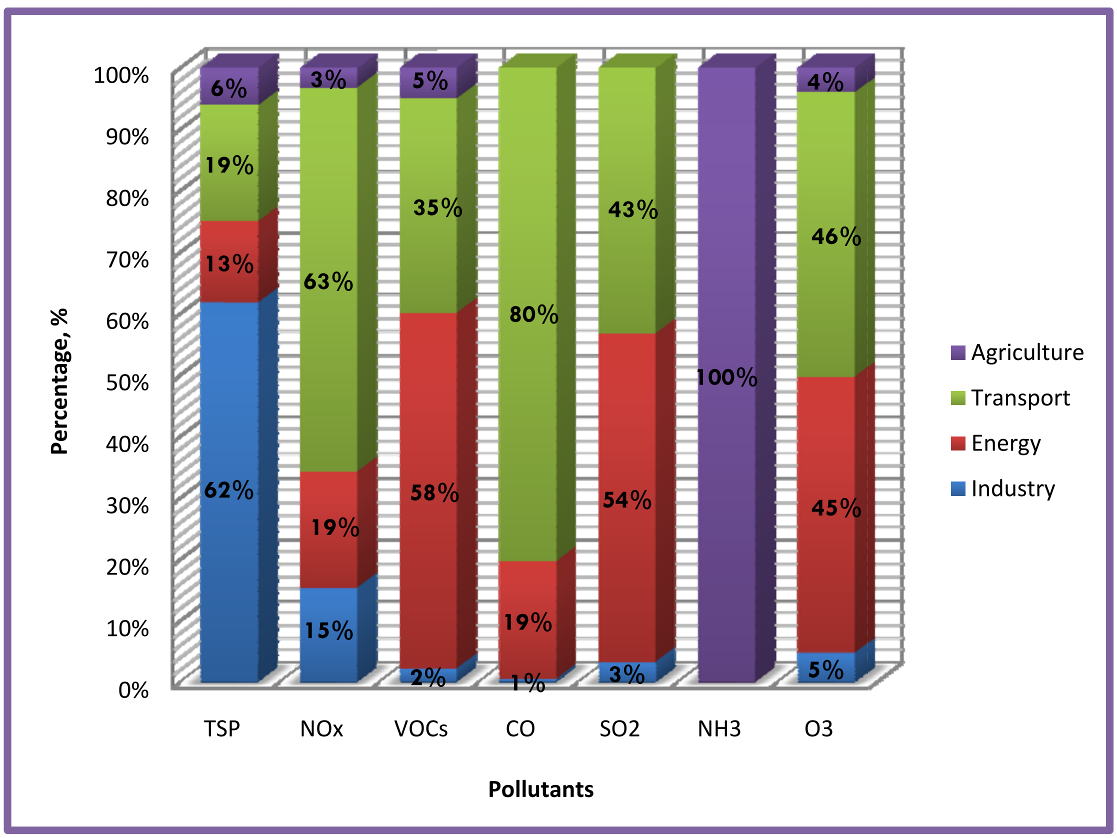


Figure 12. Percentage share of various sectors in 2012 total emissions of individual substances



As for2000-2012 trends of emissions of individual substances by different sectors,the transport sector was a leader in emissions of CO followed by the energy sector, with maximum amounts emitted in 2009. Since 2010 CO emissions from the transport sector have shown a slight decrease.Transport maintained the leading position among various sectors in emissions of NO_x, PM_{10} and O_3forming gases. Moreover, it was the largest source of SO_2 emissions from 2002 through 2009, with steadily growing emission rate. In 2010 the energy sector became the largest contributor to total SO_2 emissions, due to the switching of fuel from natural gas to local coal with high sulphur content and this trend was also maintained in 2011-2012. The industry sector accounted for the highest emissions of dust in 2000-2007, due to the operations of cement and concrete plants, with peak emissions reported for 2007. In 2008 dust emissions decreased slightly followed by drastic drop in 2009. This decrease might be attributed to reduced capacities of industries, including cement plants due to the overall economic turndown caused by 2008 Georgia-Russia war and world financial crisis as well as costly investments made in pollution abatement by the major plants owners. In 2010 dust emissions from the industry sector started to grow and reached about 2008 levels in 2012 due to increased industrial capacities. In 2009-2010 the energy sector overweighed emissions from the industry sector. As for VOCs, the energy sector was the largest contributor to total VOC emissions in 2000-2012, with peak emissions reported for 2007, significant drop is reportedfor 2008-2010 and then an increase is reportedfor 2011-2012. In 2012, dust emissions reached maximum amount among total annual dust emissions from 2000 through 2012. The agricultural sector was the second largest contributor to PM_{10} emissions from 2008-2012 after the transport sector.

Figure 13.2000-2012Industry emissions, tons

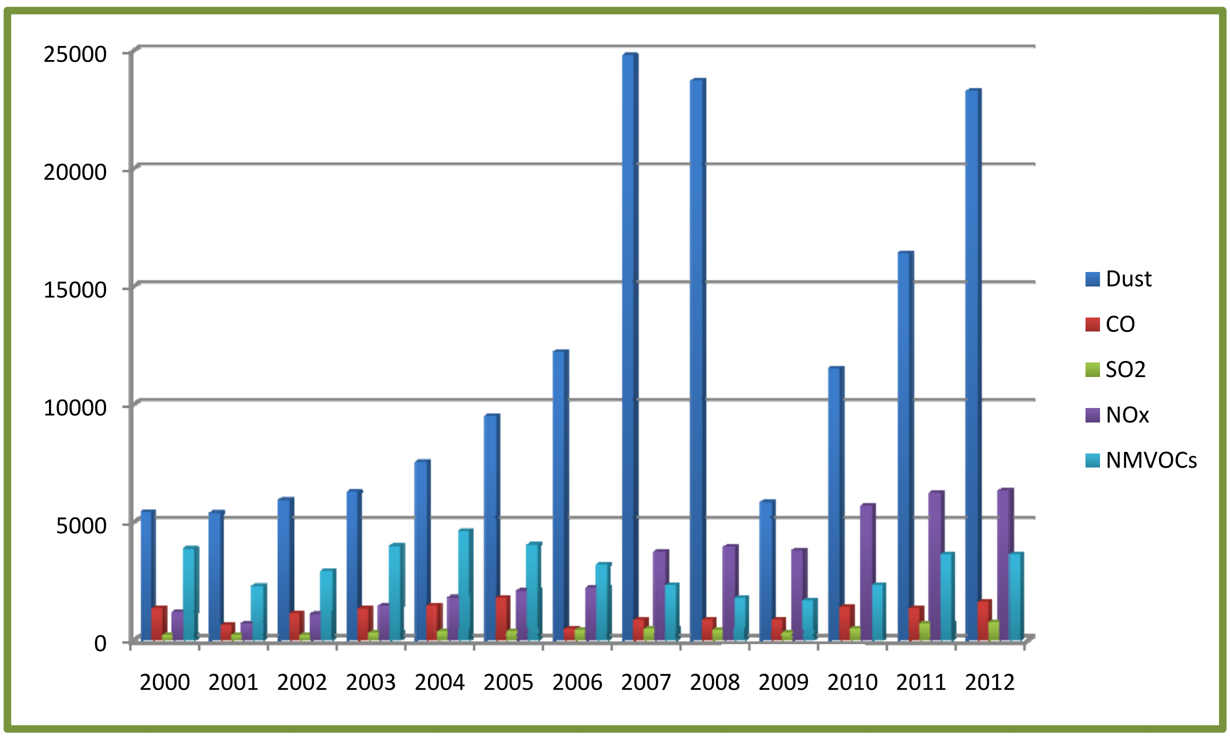


Figure 14. 2000-2012 energy sector emissions, tons

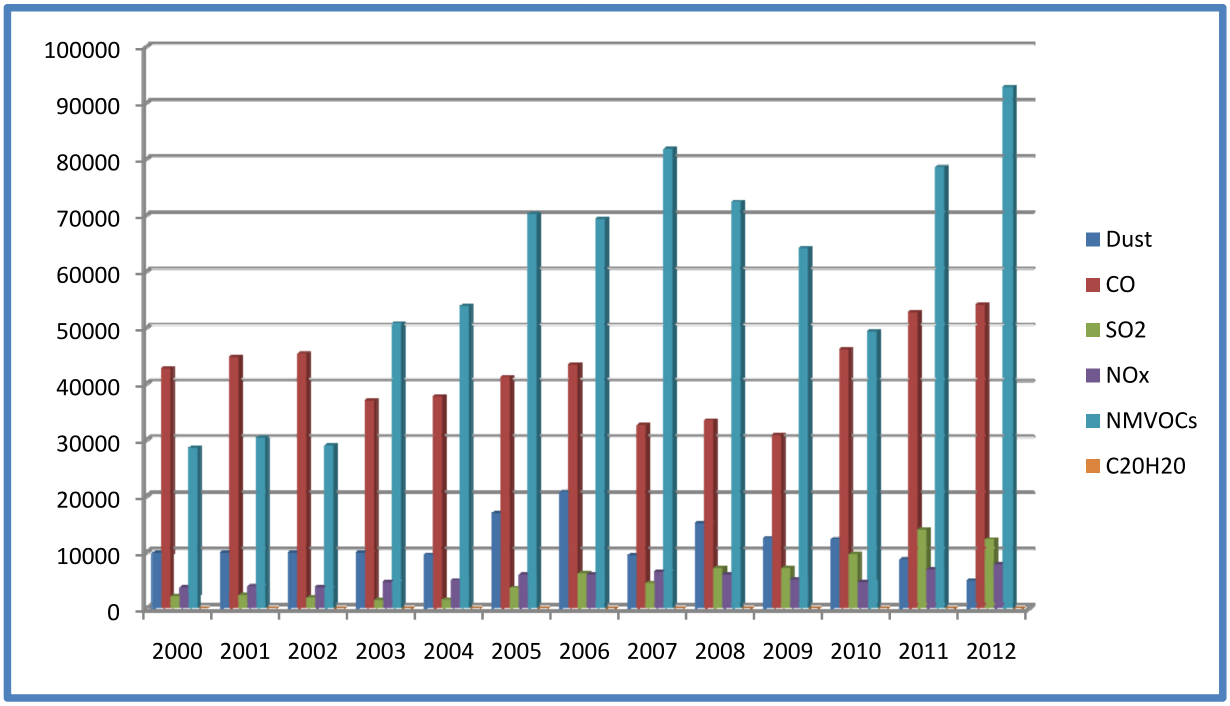


Figure 15. 2000-2012 transport emissions, tons

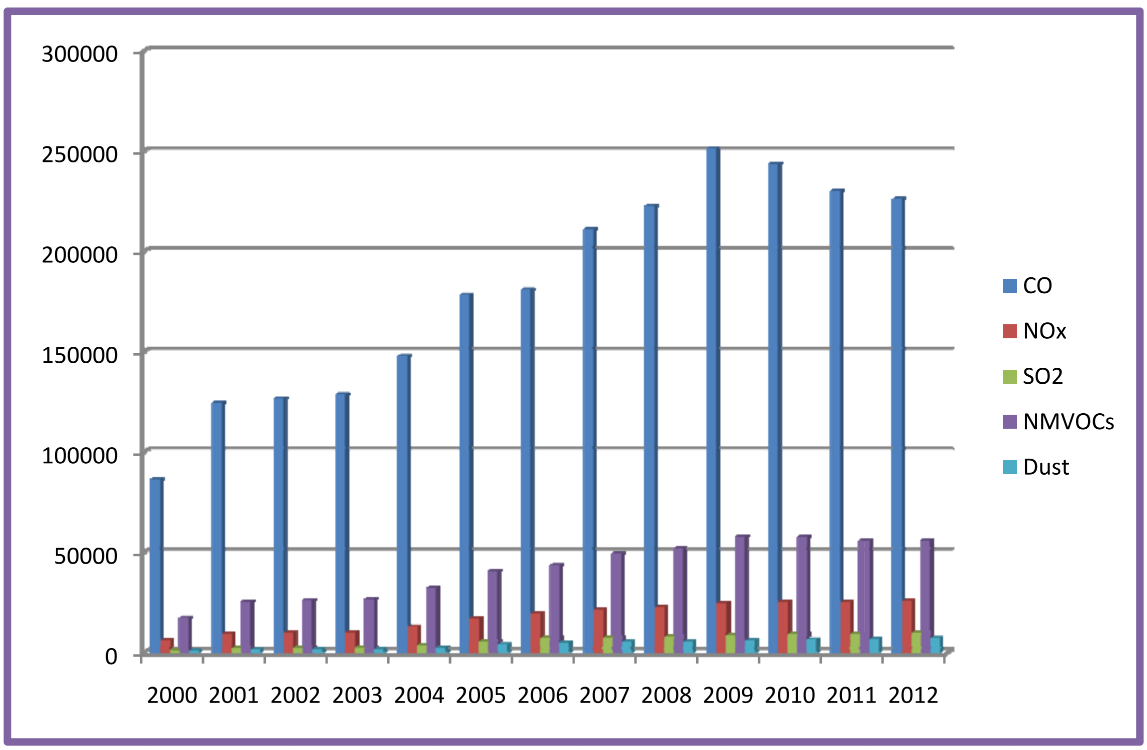
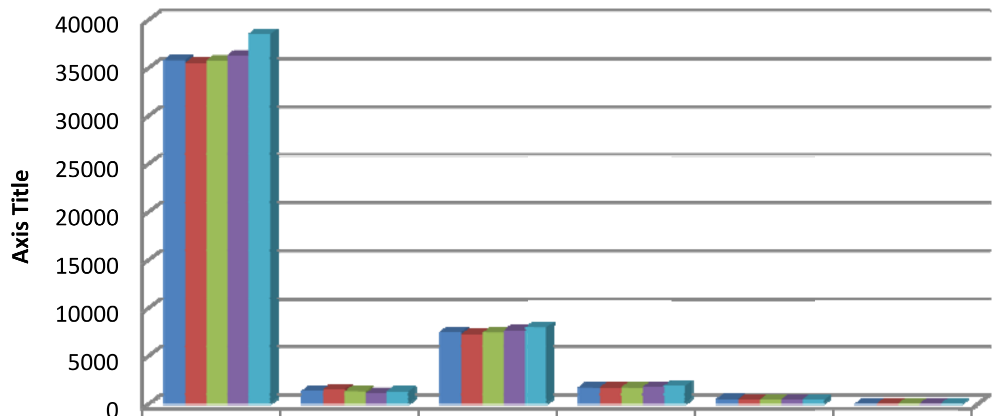


Figure 16. 2008-2012 agriculture emissions, tons



	NH3	NO	NMVOC	TSP	PM10	PM2.5
2008	35799,724	1349,5117	7494,8665	1709,6214	513,708	19,758
2009	35530,016	1524,6297	7271,0314	1706,9984	451,932	17,382
2010	35764,83	1323,5703	7427,1123	1708,5696	400,452	15,402
2011	36289,044	1143,9449	7657,8835	1732,2534	409,344	15,744
2012	38507,132	1308,6937	7958,0854	1869,0983	404,976	15,576

Figure 17. 2002-2012 NO_x emissions, tons

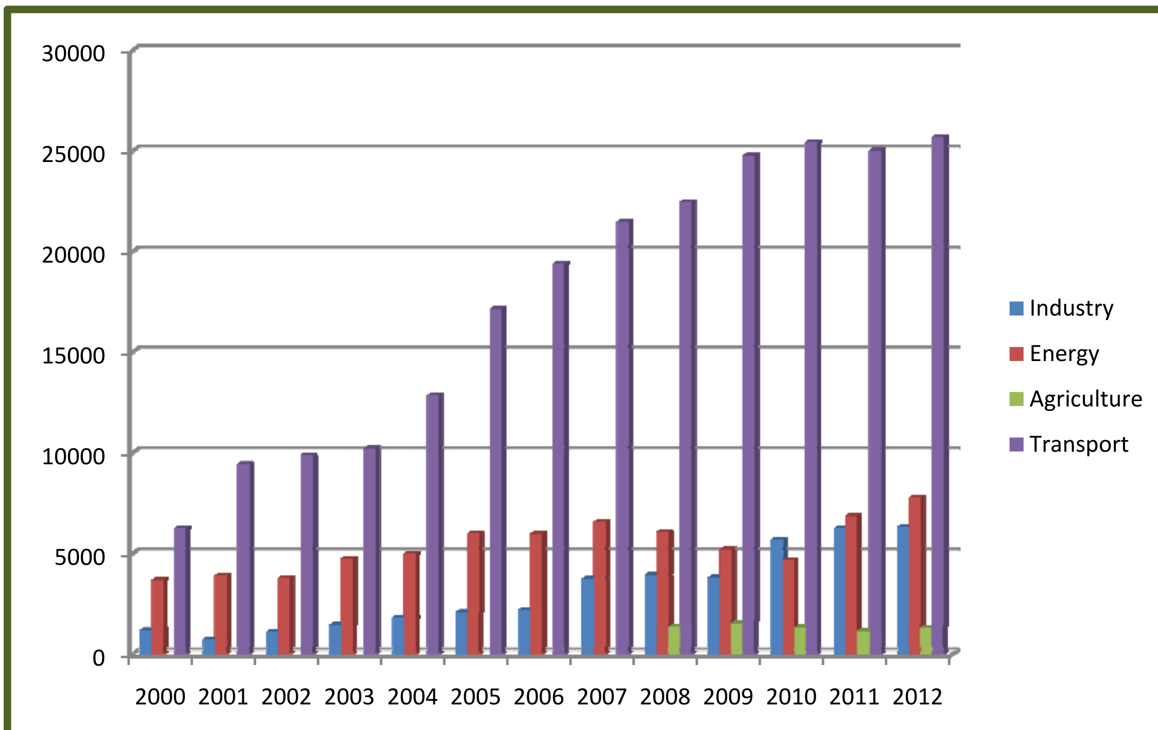


Figure 18. 2000-2012 SO_2 emissions, tons

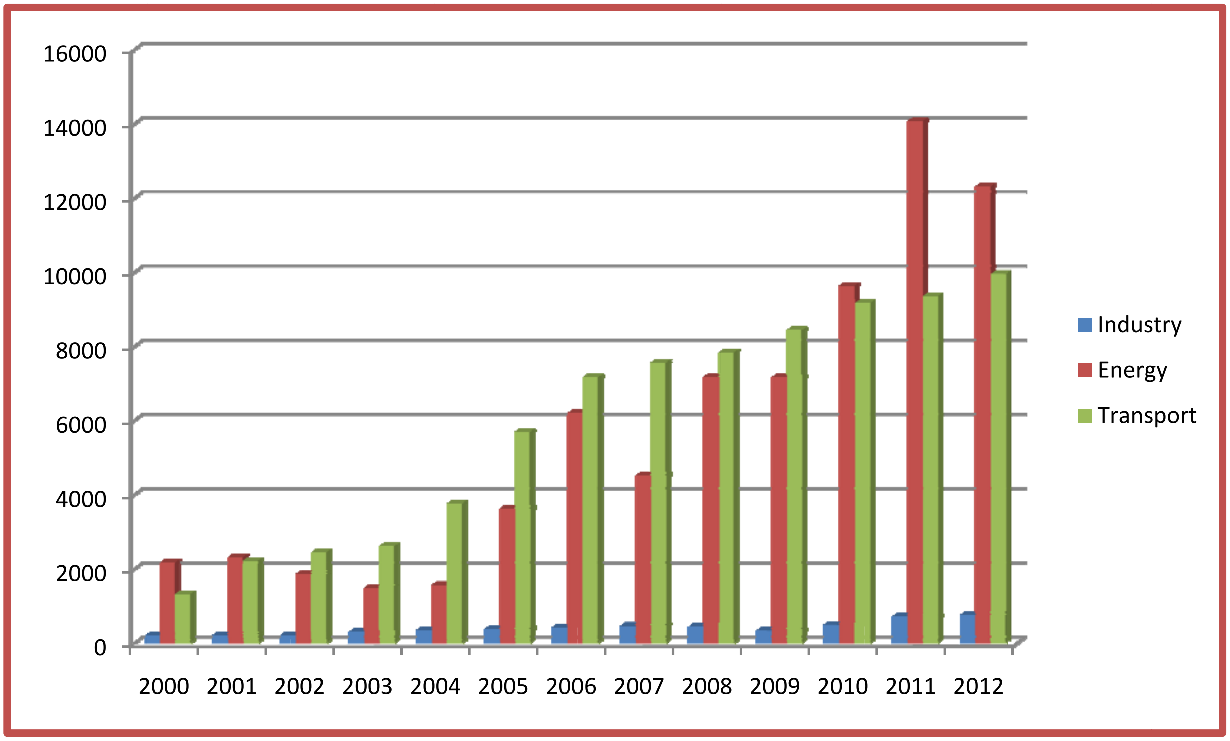


Figure 19. 2000-2012 CO emissions, tons

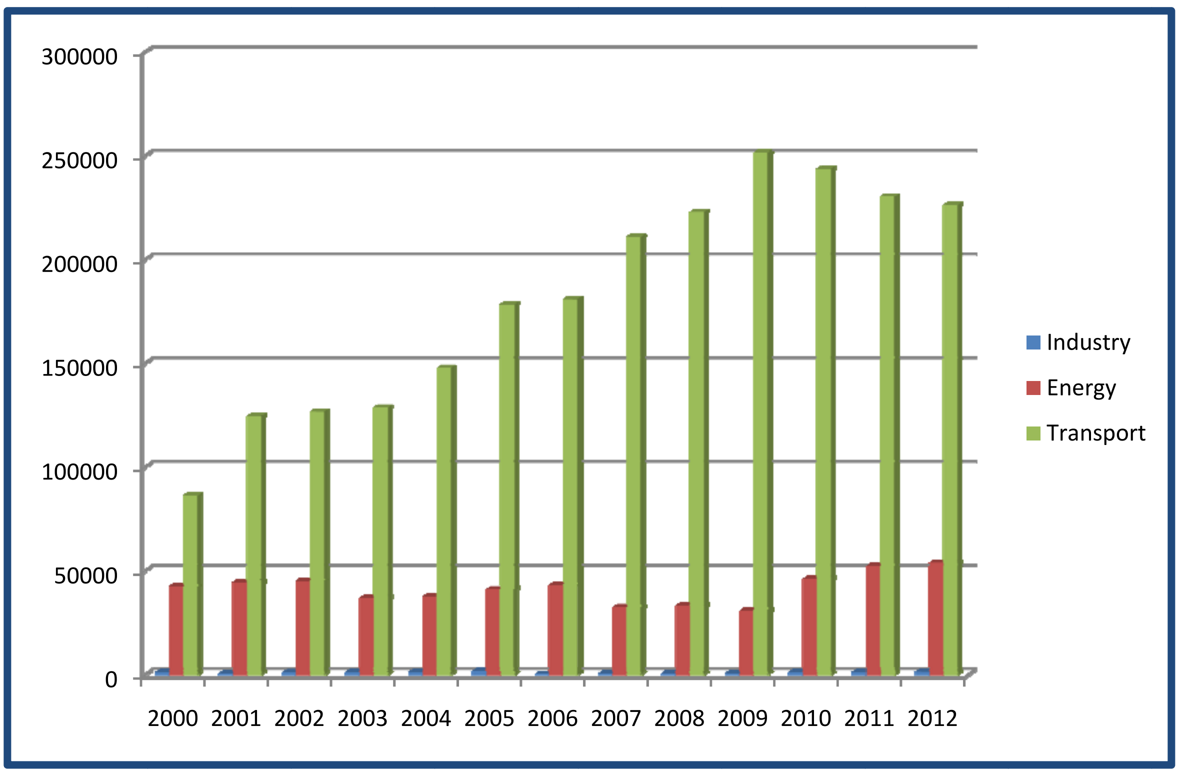


Figure 20. 2000-2012 VOC emissions, tons

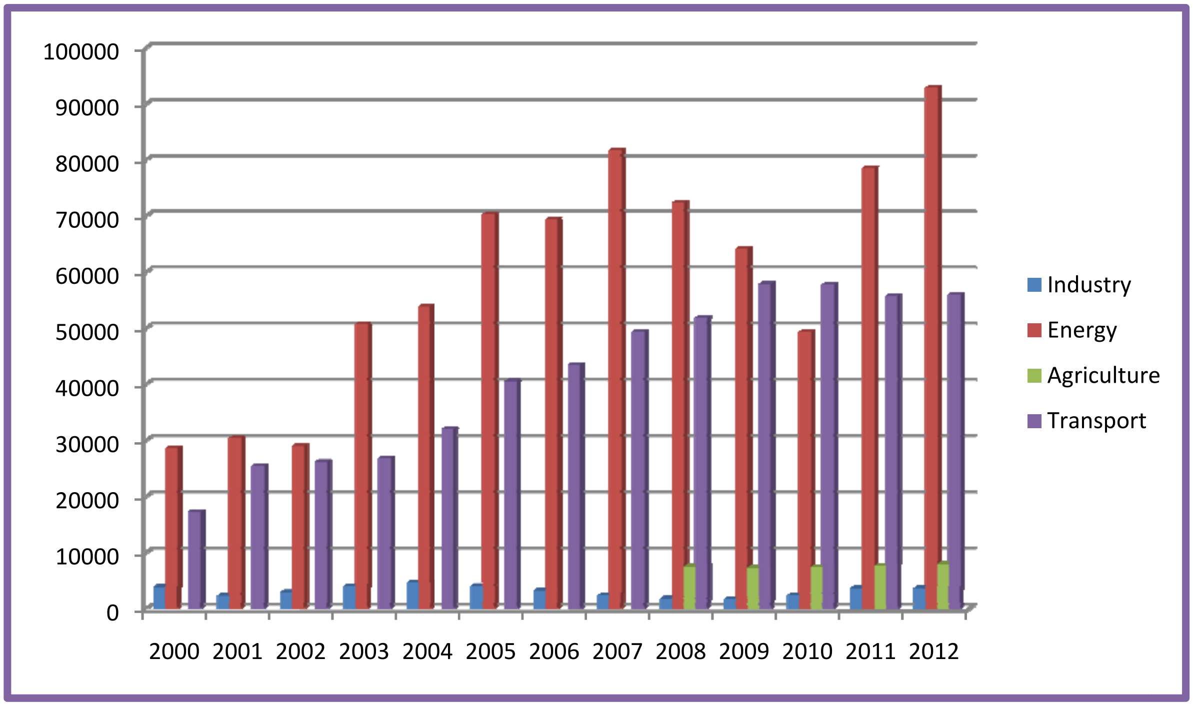


Figure 21. 2000-2012 PM_{10} emissions, tons

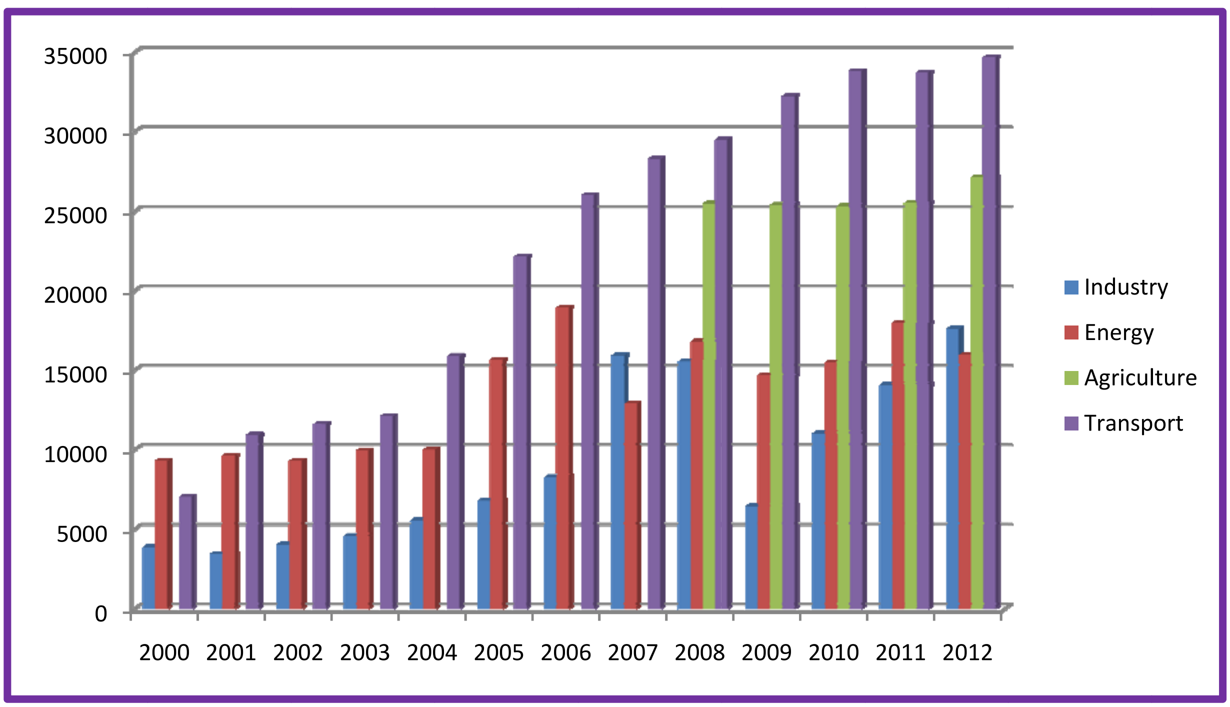
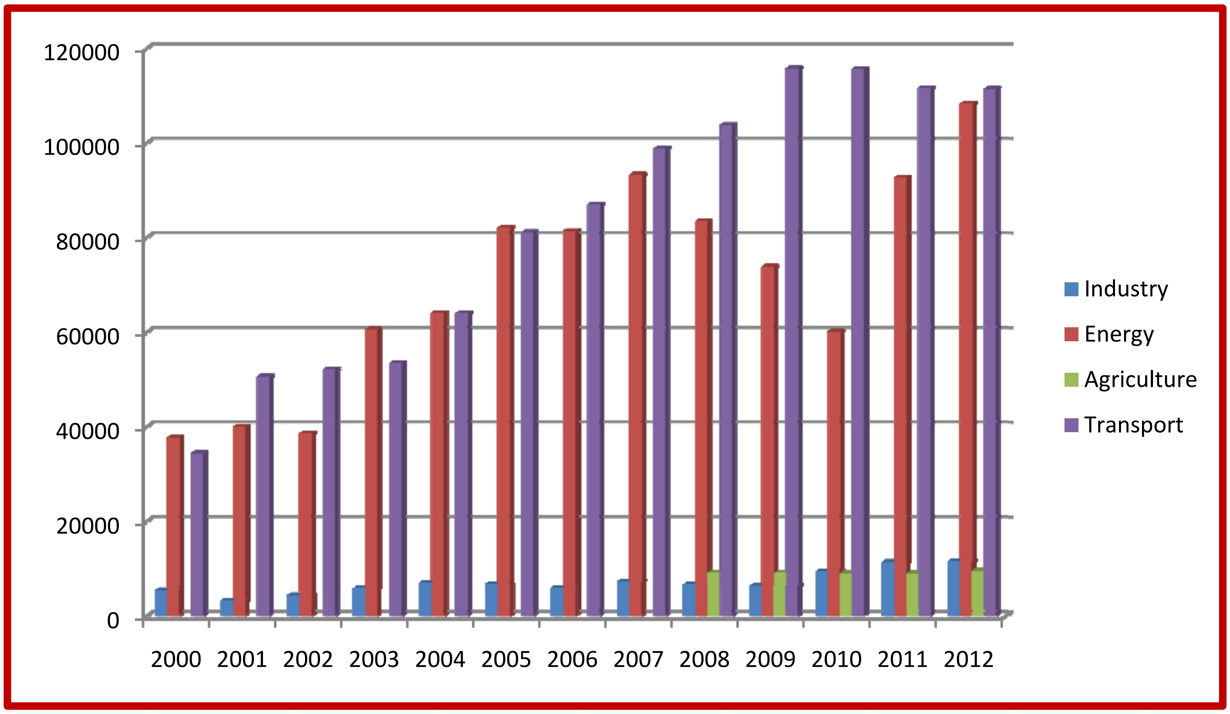


Figure 22. 2000-2012 emissions of O_3 forming gases, tons



7.2 Emissions from Point and Diffused/AreaSources

7.2.1 Emissionsfrom Point and Diffused/Area Sources by Regions

7.2.1.1 Contribution of Various Regions to Gross Emissions

In terms of contribution of various regions to total emissions of pollutants from point and area sources[16]for the period of 2004-2012, Imereti region was the largest contributor to total emissionswith 106,282.5 tons of gross emissions (42.48%), followed by Kvemo Kartli region, with 60,593.873tons of gross emissions (24.22%), Adjara with 30,340.39 tons of gross emissions (12.13%), Shida Kartli with 29,099.79 tons of gross emissions (11.63%), Samegrelo-ZemoSvaneti with 8,809.466tons of gross emissions (3.52%), Mtskhetai-Mtianeti with 5,141 tons of emissions (2.05%) and Tbilisi with 4,075.812tons of emissions (1.63%). Remaining regions togethermade up5,847.42tons of emissions (2.34%).

[16] These data only include emissions from point and diffused/area sources of pollution subject to annual emission inventories and reporting to the MoENRP

Figure 23. Percentage share of various Regions in 2004-2012 gross emissions

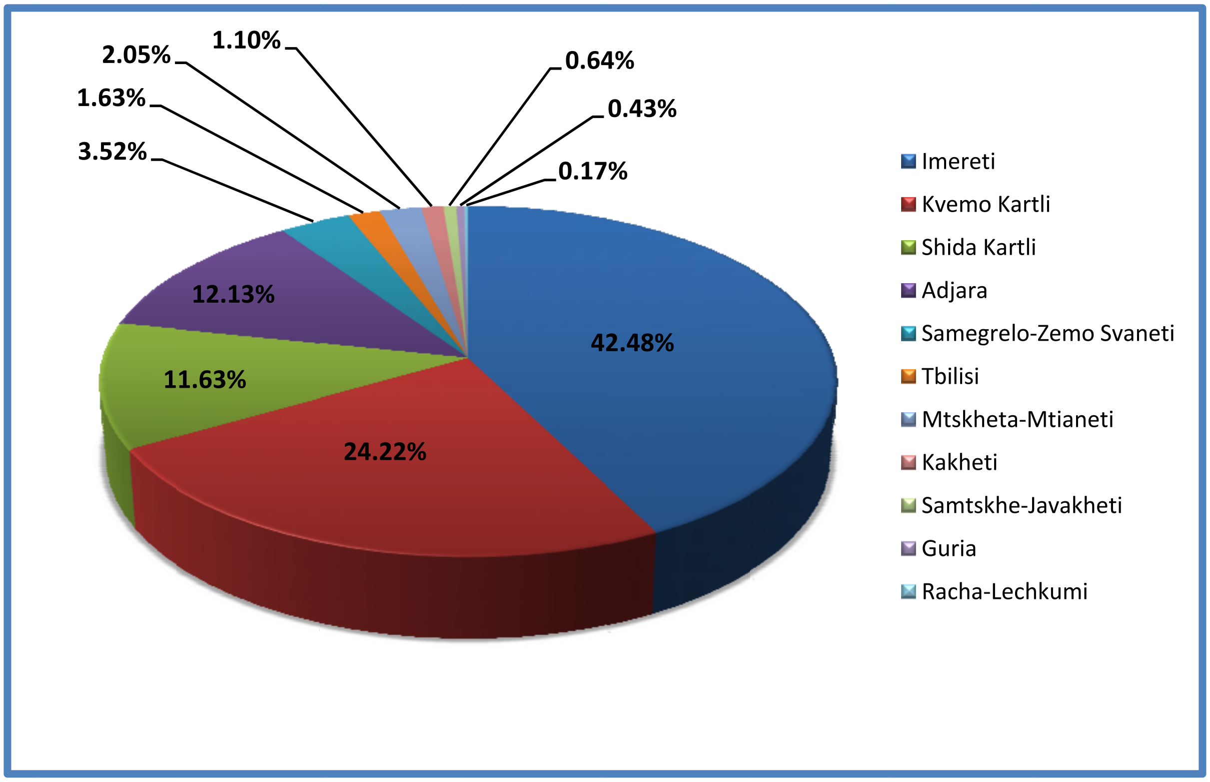


Figure 24. Emissions of various substances in KvemoKartli, tons

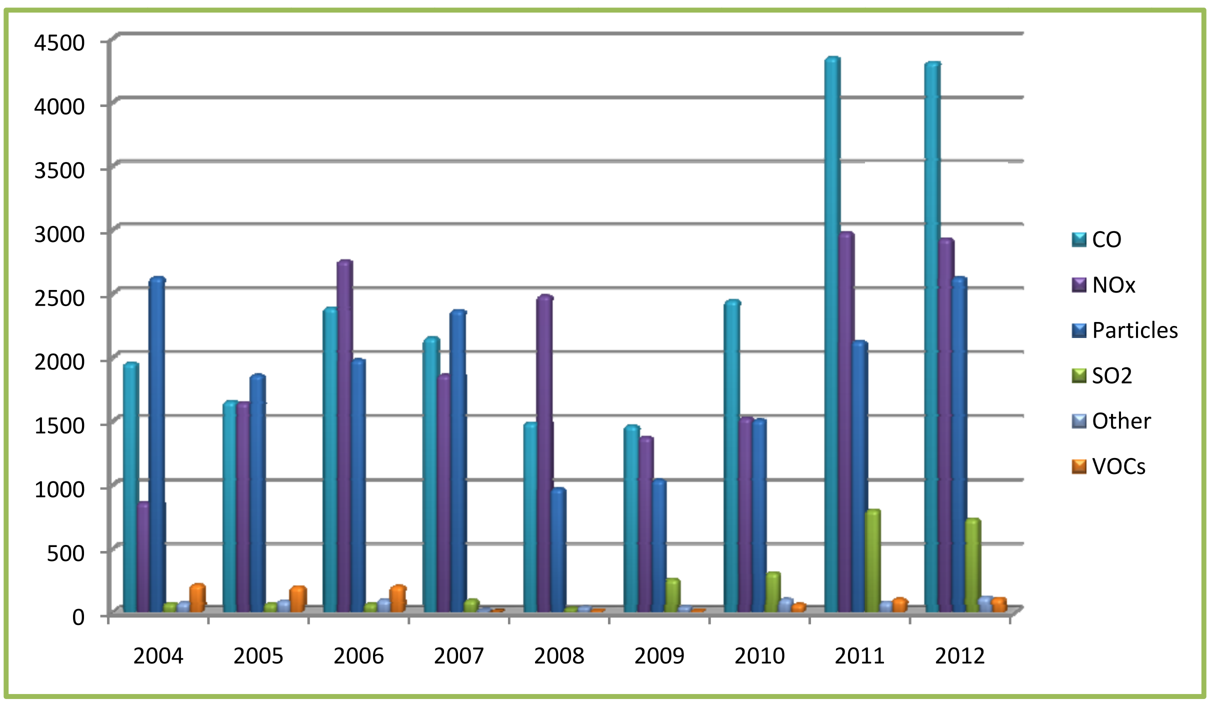


Figure 25. Emissions of various substances in Imereti, tons

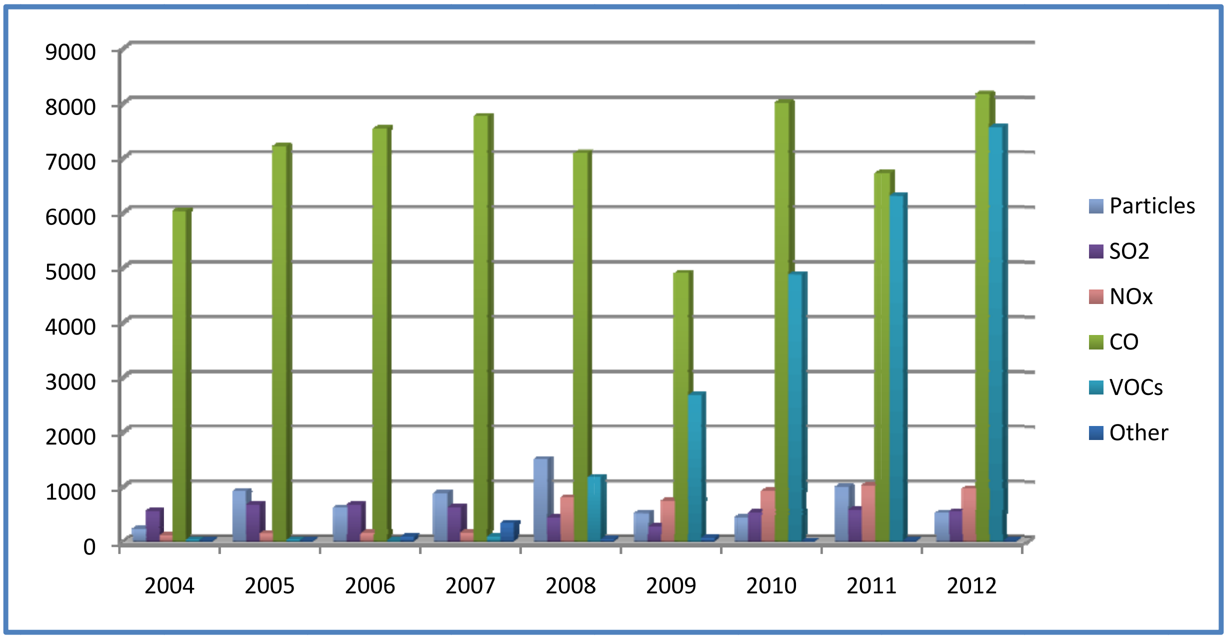
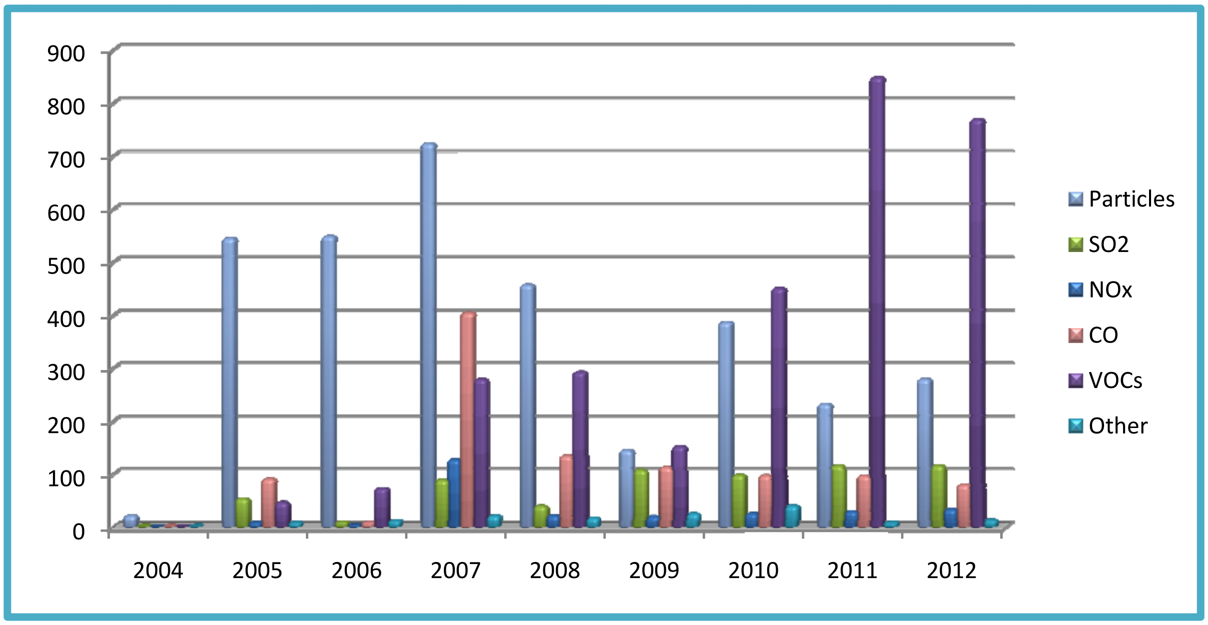
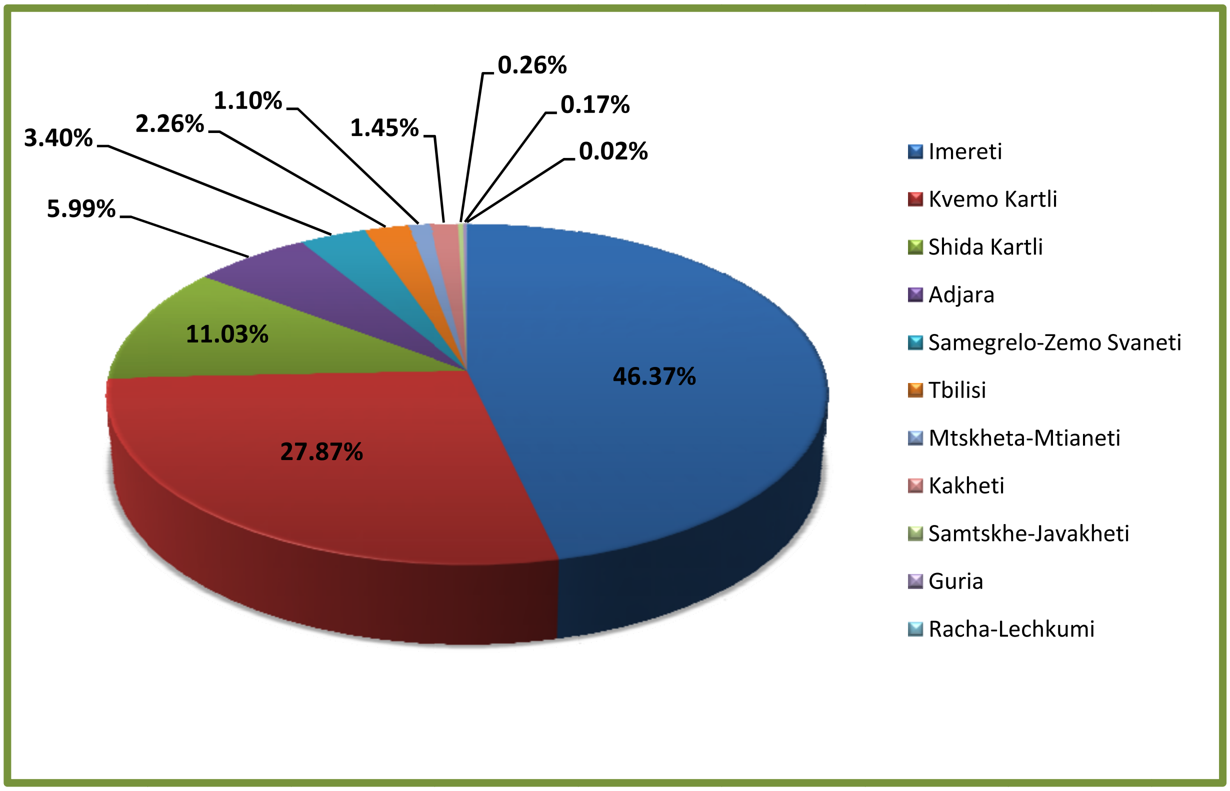


Figure 26. Emissions of various substances in Samegrelo, tons



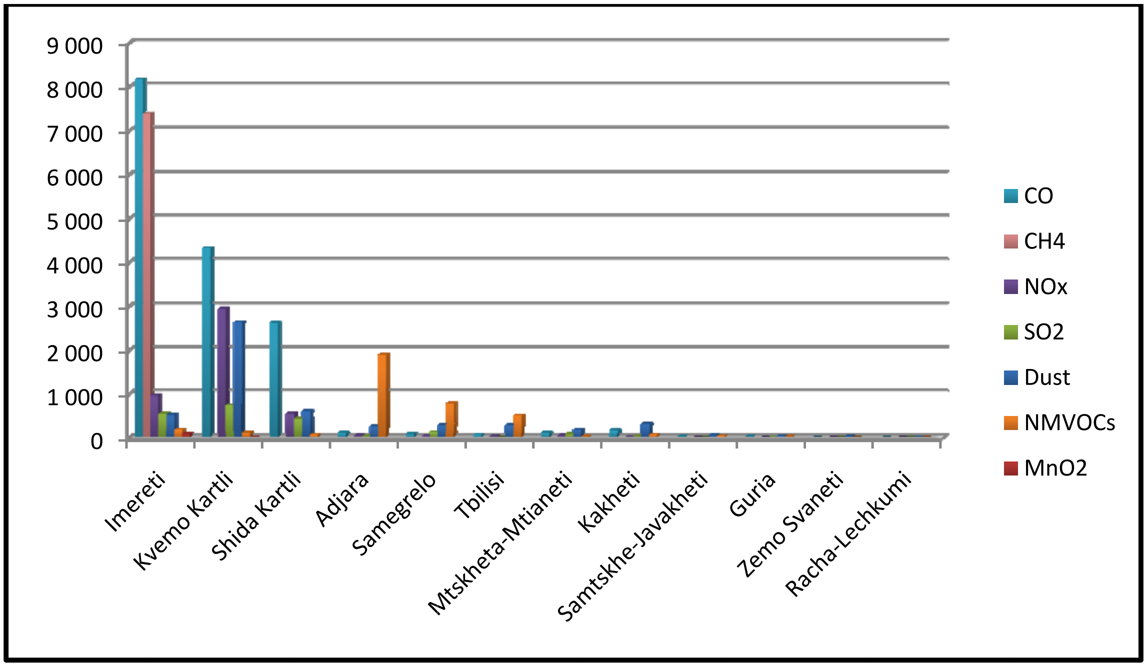
In 2012, total point and diffused sources of emissions subject to emission registration and reporting, amounted to 38,392tons, with Imereti region making up 46.37% of gross emissions, KvemoKartli – 27.87%, ShidaKartli -11.03%, Adjara – 5.99%, Samegrelo-ZemoSvaneti – 3.40%, Tbilisi – 2.26%, Kakheti – 1.45%, Mtskheta-Mtianeti – 1.10% and the rest of the regions – 0.53%.

Figure 27.Georgian regions' % share of 2012 gross national emissions



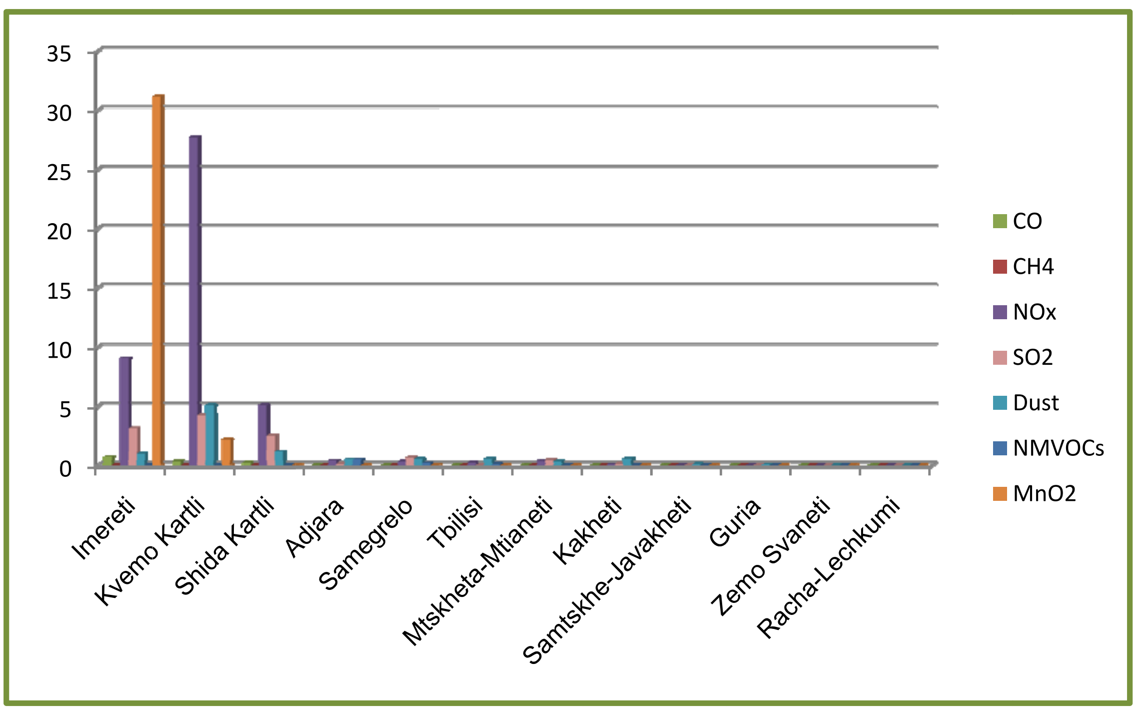
While Imereti contributed the highest share to total CO and CH_4 emissions due to the coal extraction and processing and operations of ferroalloy plant in Zestaponi, KvemoKartli contributed the highest share to total dust, NO_x and SO_2 emissions due to cement, metallurgical and nitrogen plants operations in Rustaviand, Adjara - the highest share to NMVOCs emissions, due to fugitive emissions from oil terminal. Emissions of manganese oxides were only associated with Imereti region, due to the manganese extraction, enrichment and its use in production of ferroalloy.

Figure 28. 2012 emissions of pollutants per regions, tons



In terms of hazard rank, the highest share was made by Imereti region, due to manganeseoxides emissions from ferroalloy plant in Zestaponi, followed by KvemoKartli and Imereti in terms of NO_X emissions.

Figure 29. Contribution of various regions to air pollution by hazardous



substances/hazard rank

In terms of emission distribution per square kilometre, Imereti region maintained the leading positionwith16 t/km^2 emission density, followed by KvemoKartli region with 11.063

t/km^{2}emission density, Adjara autonomous republic with 10.462 t/km^2 emission density, Tbilisi with, and the city of Tbilisi with 8.078 t/km^2 emission density, ShidaKartli region with 4.694 t/km^2 emission density, Samegrelo-ZemoSvaneti with 1.184 t/km^2 emission density and Samtskhe-Javakheti with 0.758 t/km^2 emission density (figures and maps on emission distribution per regions are given below)

Figure 30. Distribution of 2012 emissions (tons) among regions of Georgia, tons

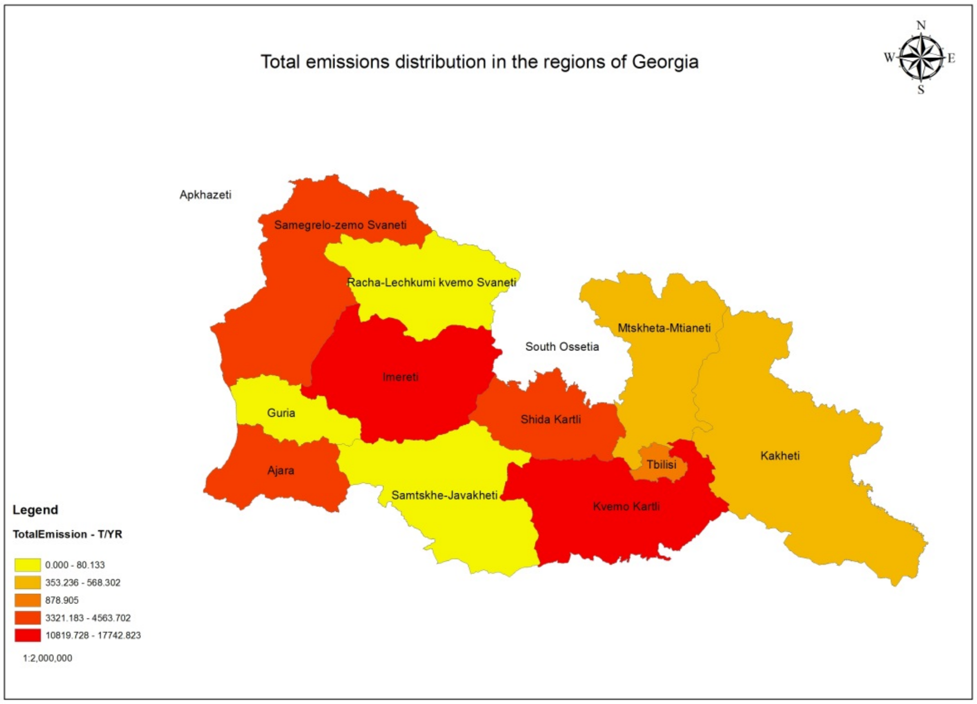


Figure 31. 2012 total emissions (t/sq. km) per regions of Georgia

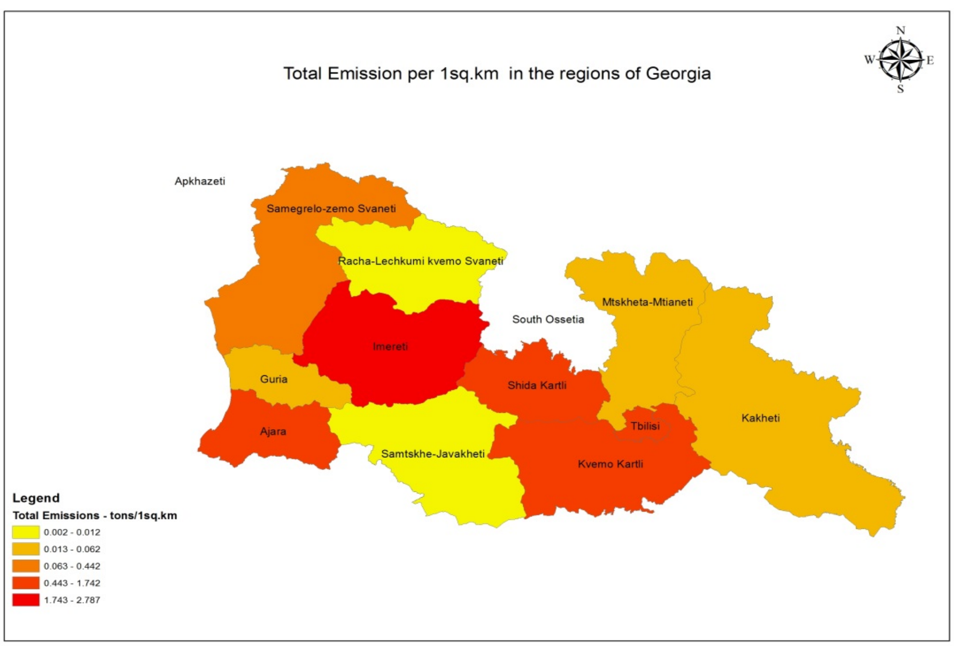


Figure 32. Distribution of 2012 NO_x emissions (tons) among regions of Georgia

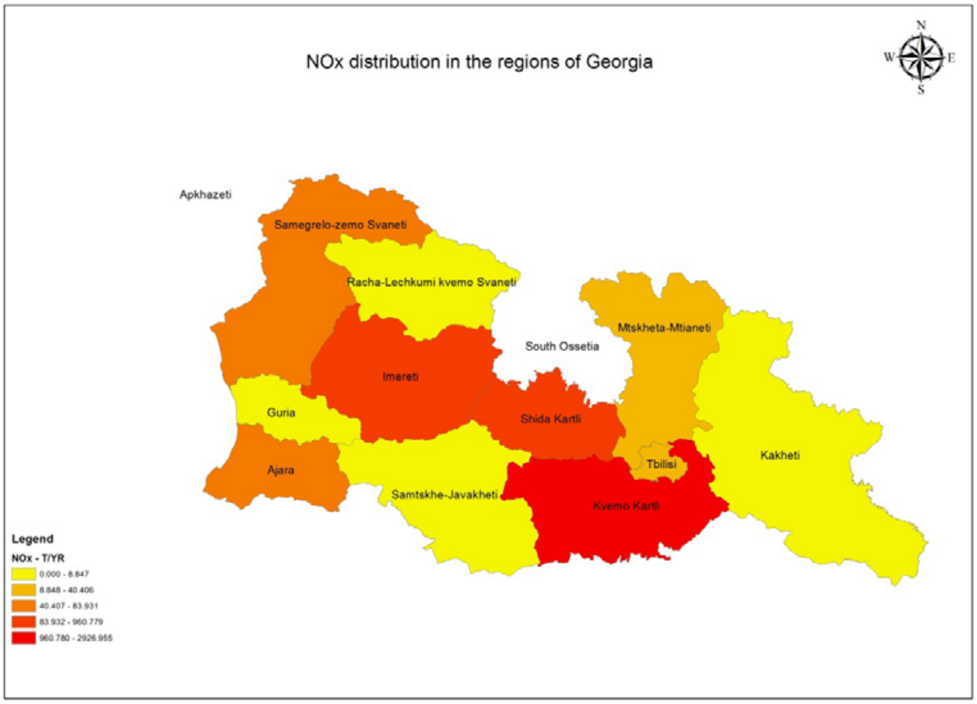


Figure 33. 2012 NO_X emissions (t/sq. km) per regions of Georgia

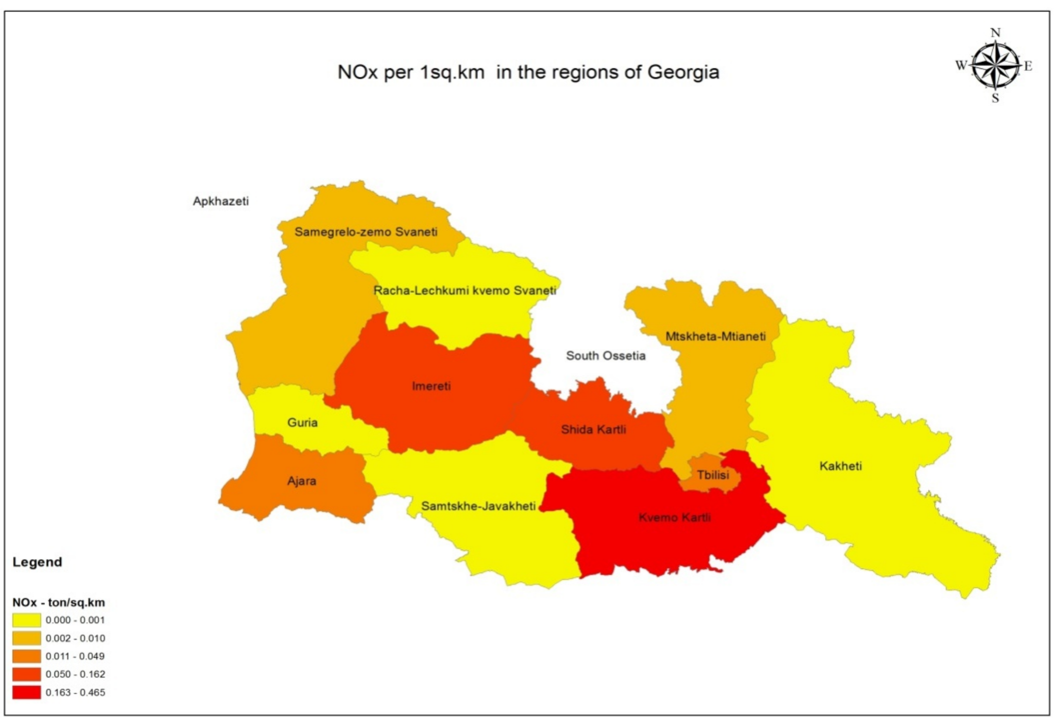


Figure 34. Distribution of 2012 SO_2 emissions (tons) among regions of Georgia,

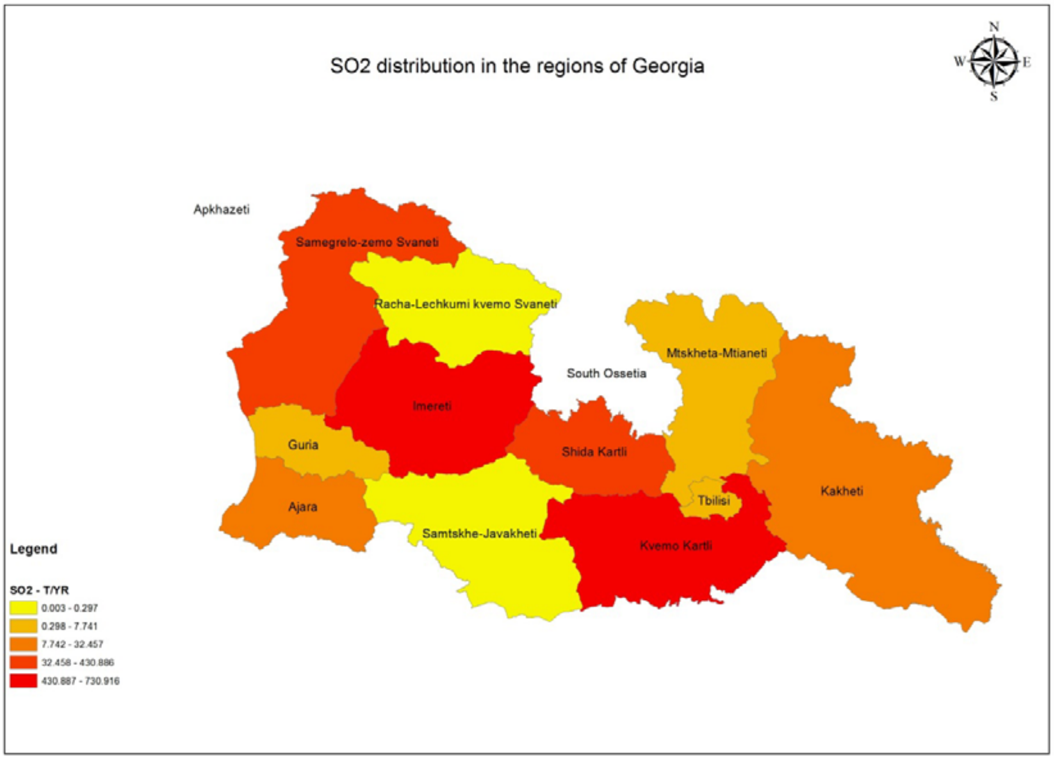


Figure 35. 2012 SO_2 emissions (t/sq. km) per regions of Georgia

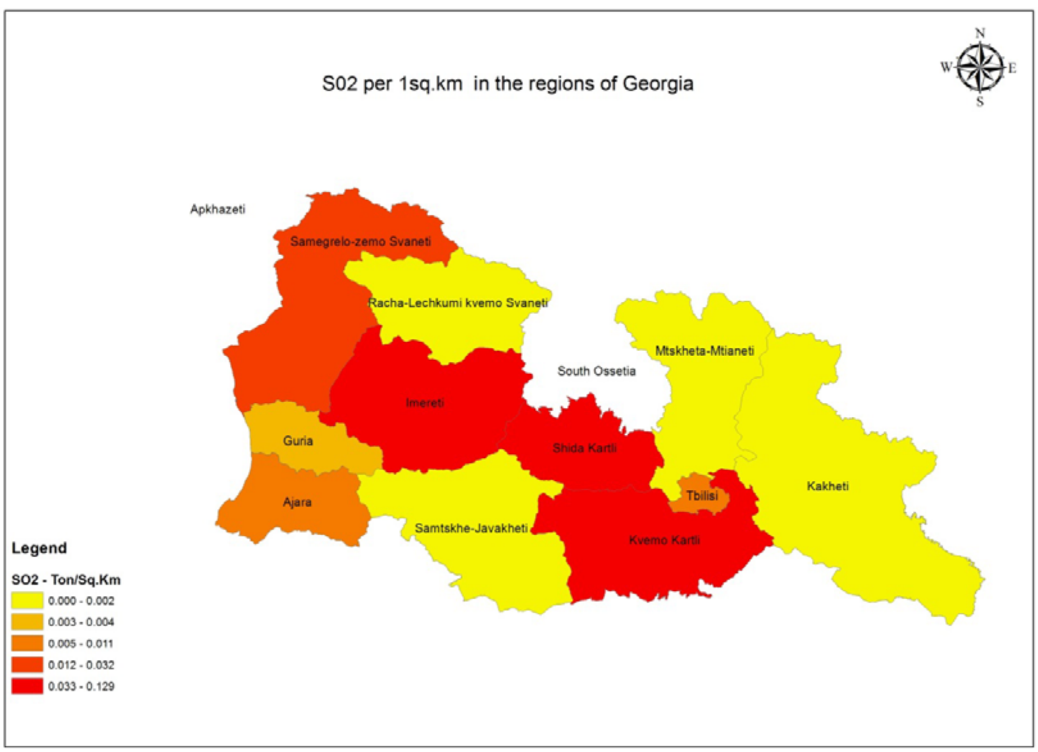


Figure 36. Distribution of 2012 TSP emissions (tons) among regions of Georgia

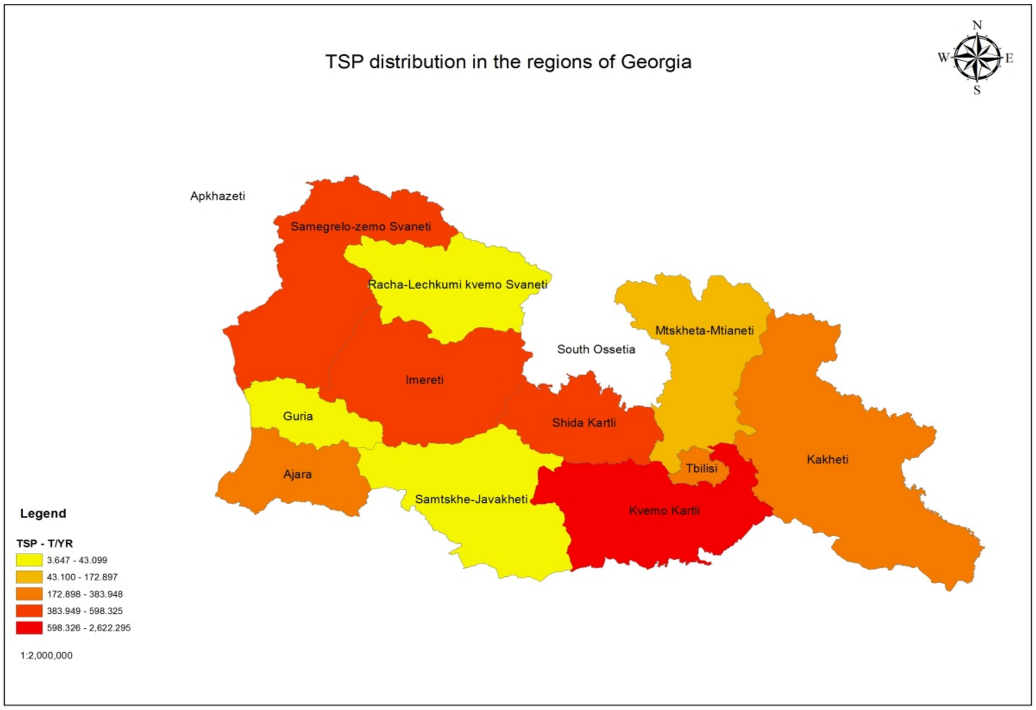


Figure 37. 2012 TSP emissions (t/sq. km) per regions of Georgia

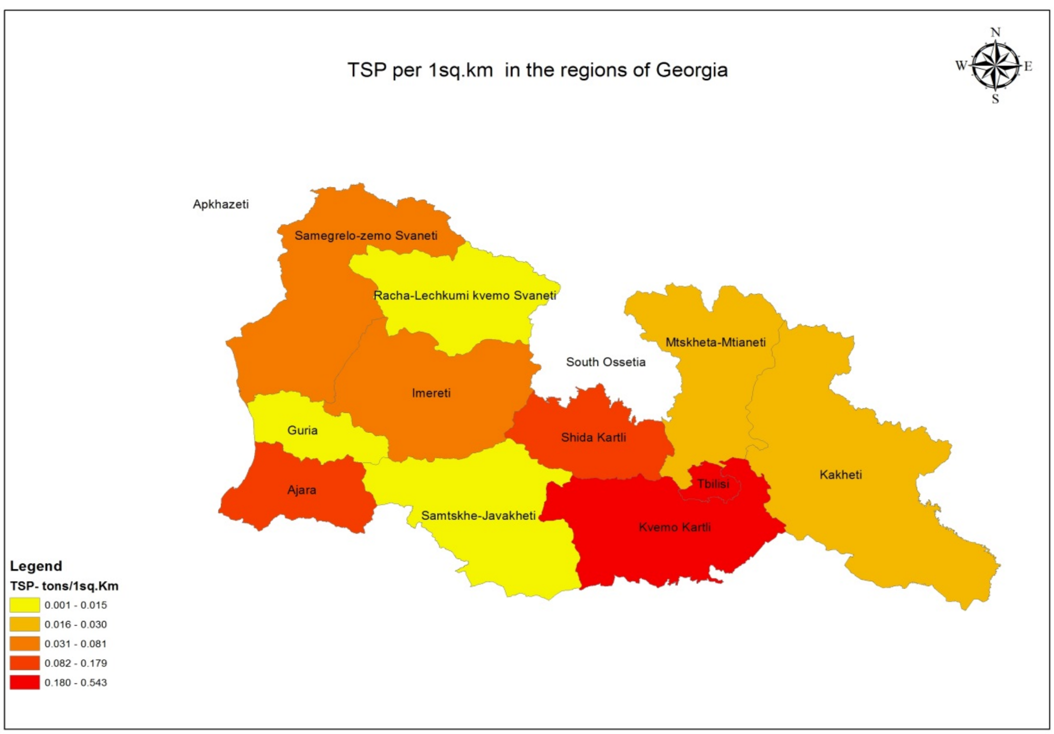


Figure 38. Distribution of 2012 VOCs emissions (tons) among regions of Georgia

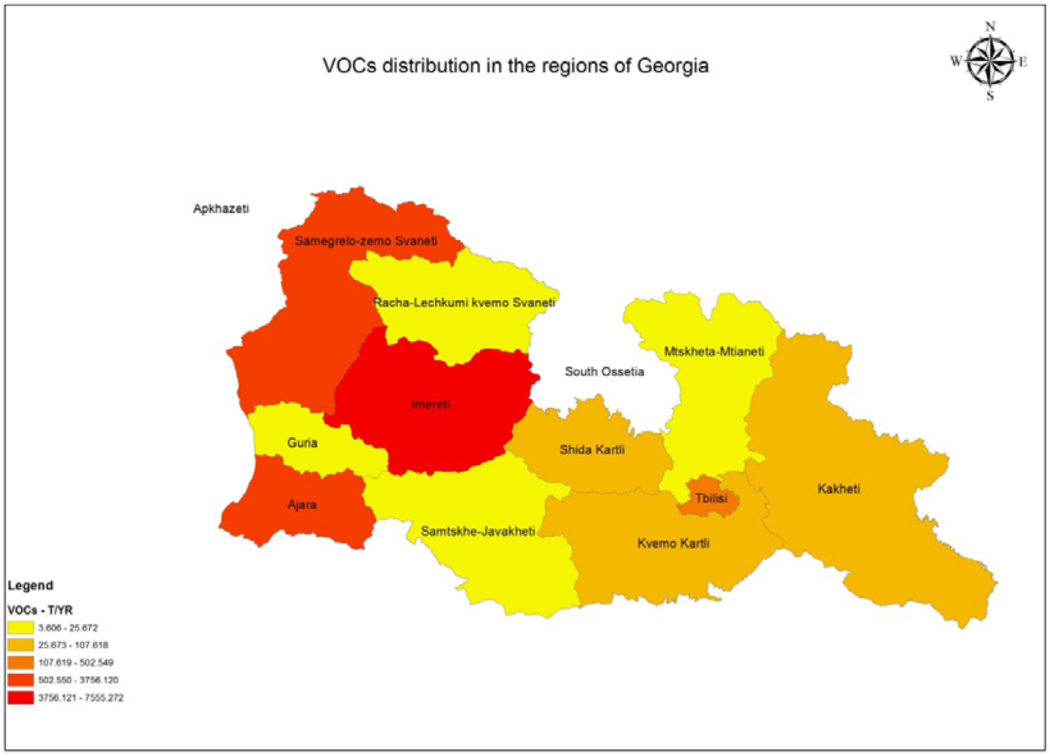


Figure 39. 2012 VOCs emissions (t/sq. km) per regions of Georgia

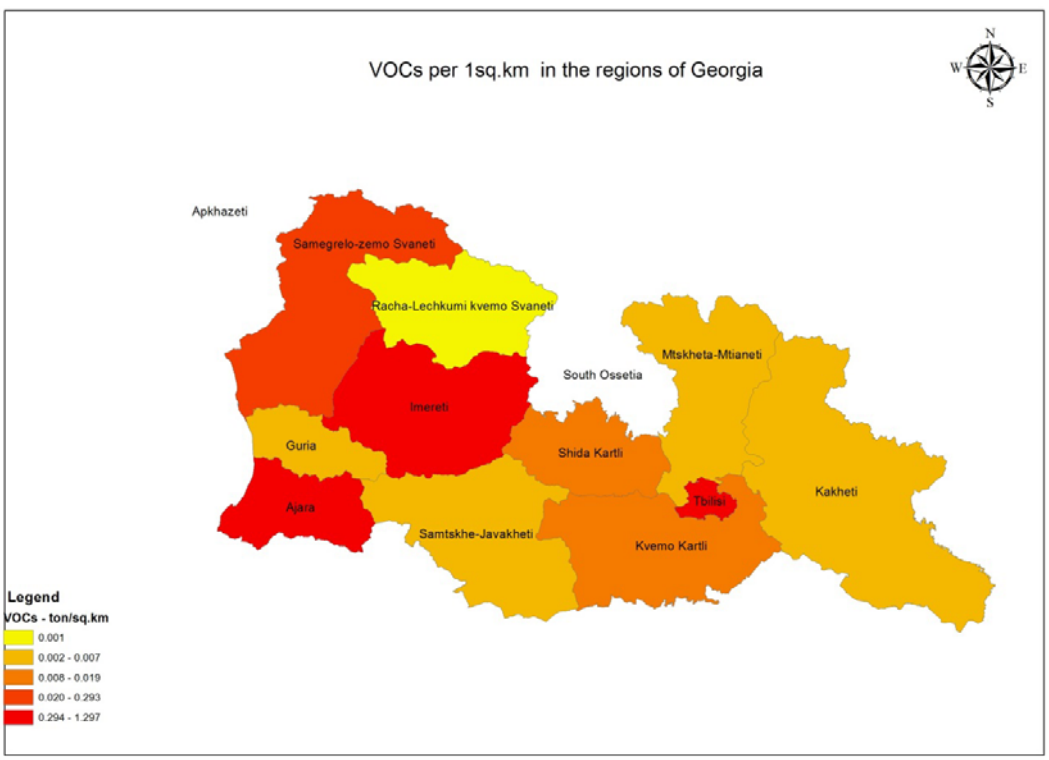


Figure 40. Distribution of 2012 CO emissions (tons) among regions of Georgia

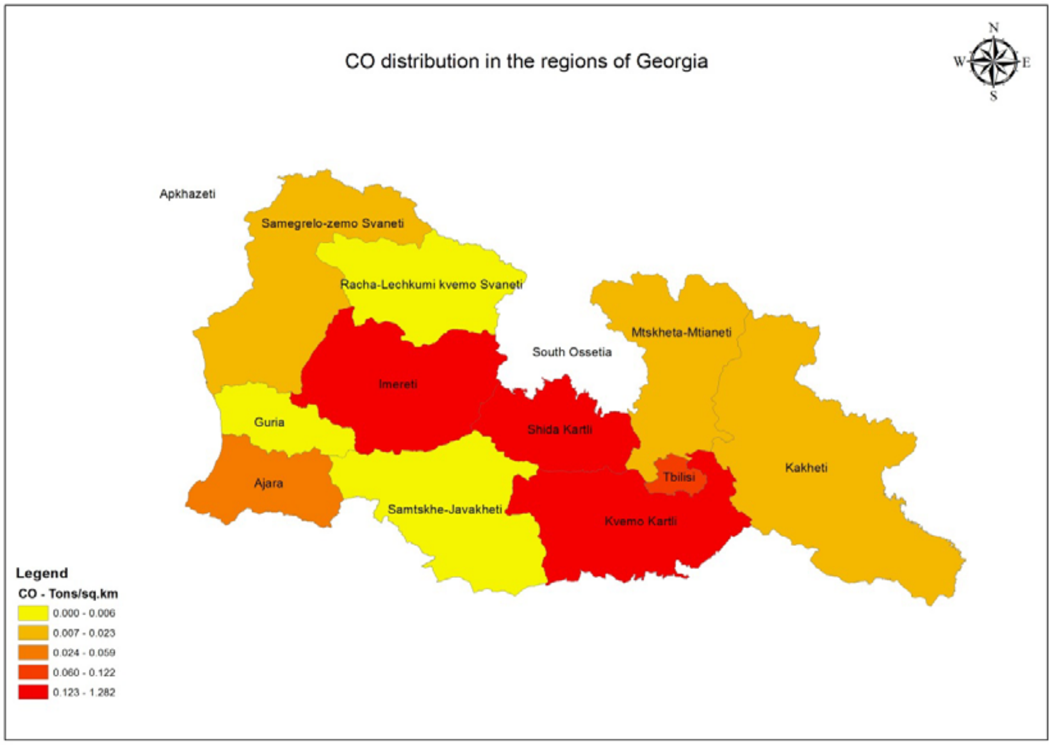
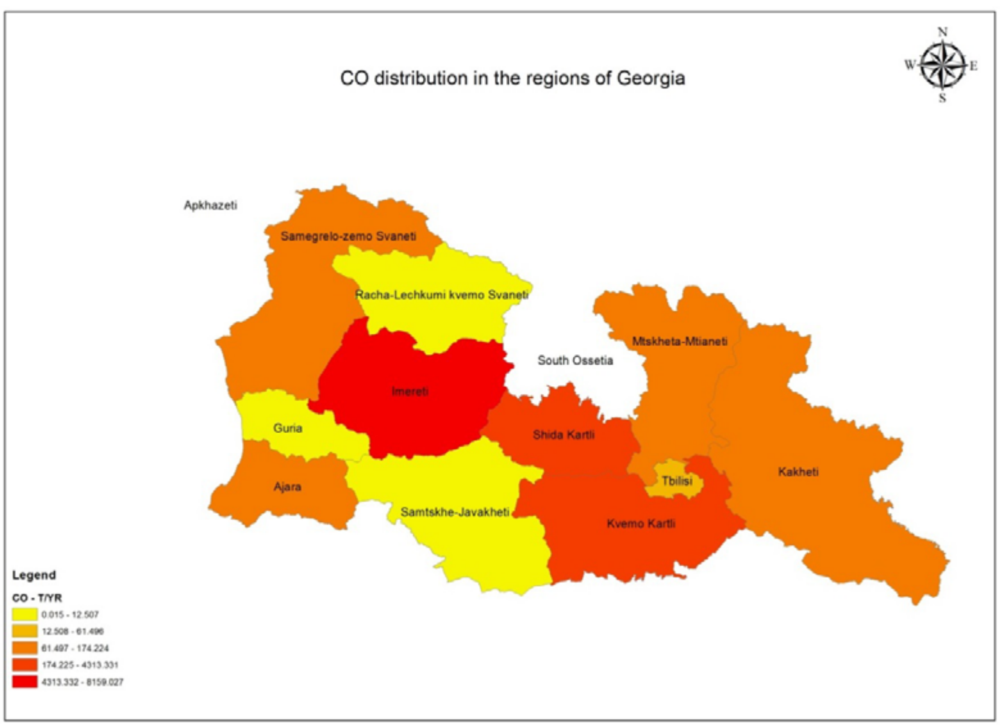


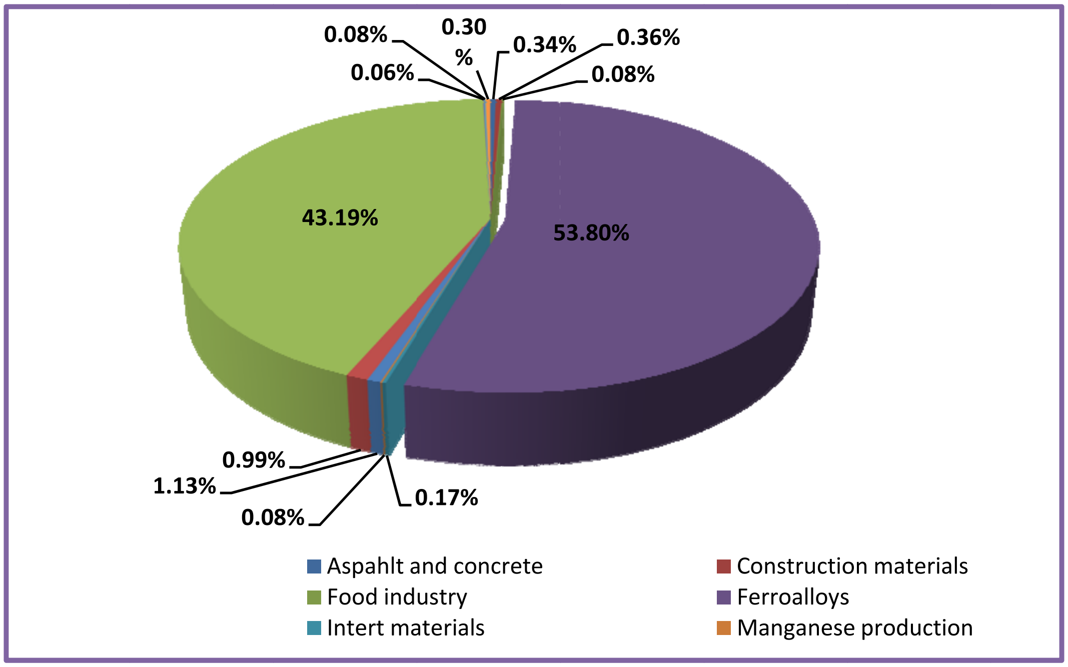
Figure 41. 2012 CO emissions (t/sq. km) per regions of Georgia



7.2.1.2Sectoral Profile of Emissions of Georgian Regions

In Imeret regionthe largest contributor to gross regional emissions from point and area/diffused sources was ferroalloys production (53.80%) in Zestaponi, followed by coal production (43.19%) in Tkibuli.

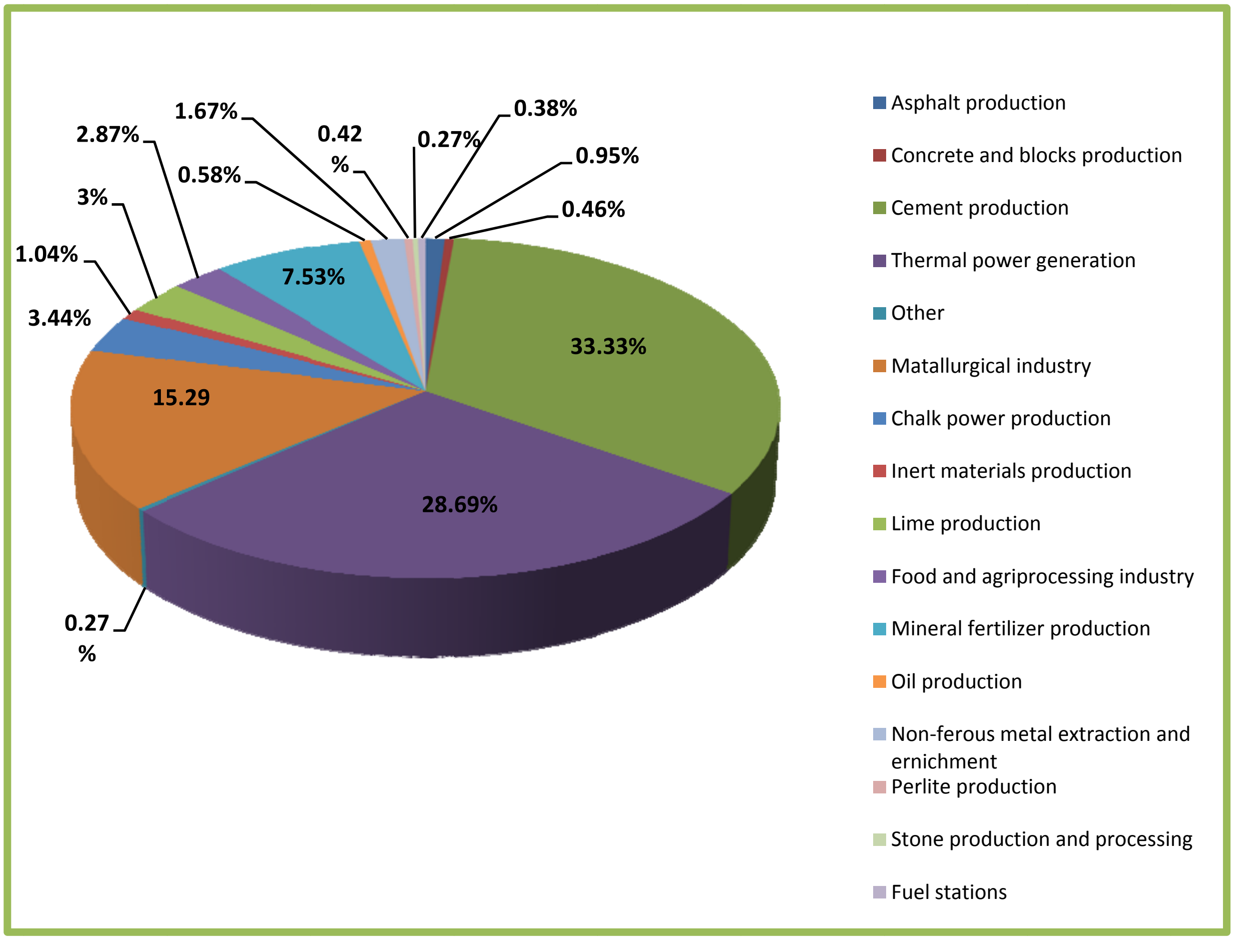
Figure 42. Sector contribution to 2012 gross emissions of Imereti region



In terms of hazard rank, the largest contributors to air pollution of Imereti region are ferroalloy production (95.65%) in Zestaponi, manganese production (extraction and enrichment, 1.61%) in Chiatura and coal production (1.48%) in Tkibuli.

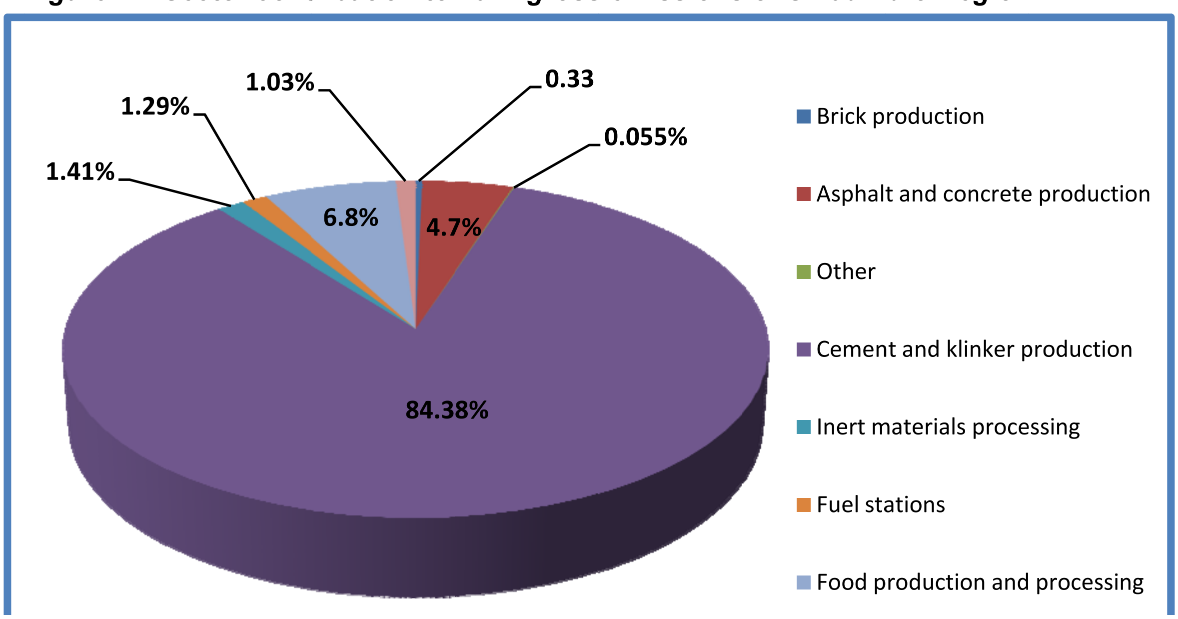
In KvemoKartli region, the largest contributors to total regional emissions werecement production industries (33.33%) concentrated in the city of Rustavi, followed by thermal power generation (28.69%), steel manufacturing (15.29%), nitrogen fertilizer production (7.53%), chalk powder production (3.44%), lime production (3%), food production and agri-processing (2.87%), non-ferrous metal production and processing (1.67%) and inert materials production (1.04%). Other sectors (oil production, recycling of used oils, food production, etc.) together made up 3.33%.

Figure 43. Sector contribution to 2012 gross emissions of Kvemo Kartli Region



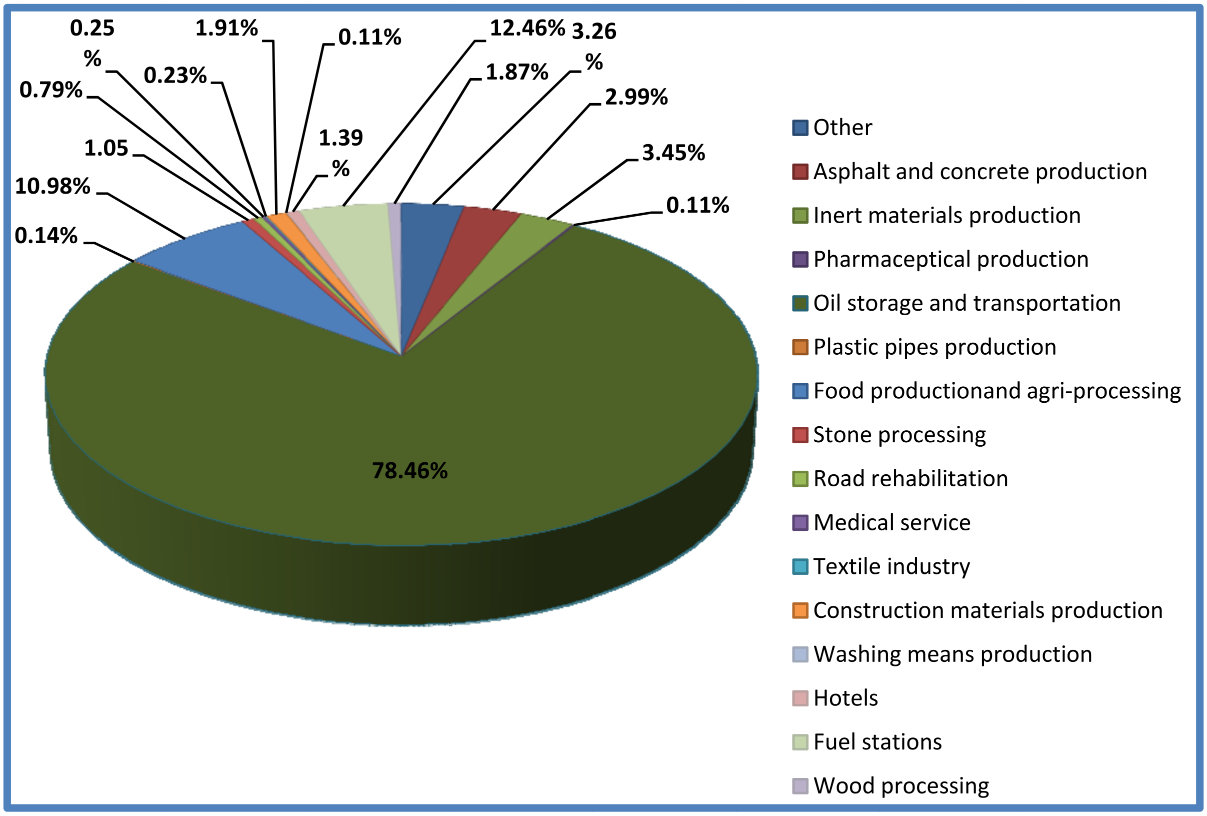
In Shida Kartli region, the largest contributor to gross regional emissions was cement and clinker production (84.38%), followed by food production and processing (6.8%) and asphalt and concrete production (4.7%). Remaining sectors (e.g. wood processing, zeolite production and processing, construction materials production, etc.) together made up 4.12%.

Figure 44. Sector contribution to 2012 gross emissions of Shida Kartli region



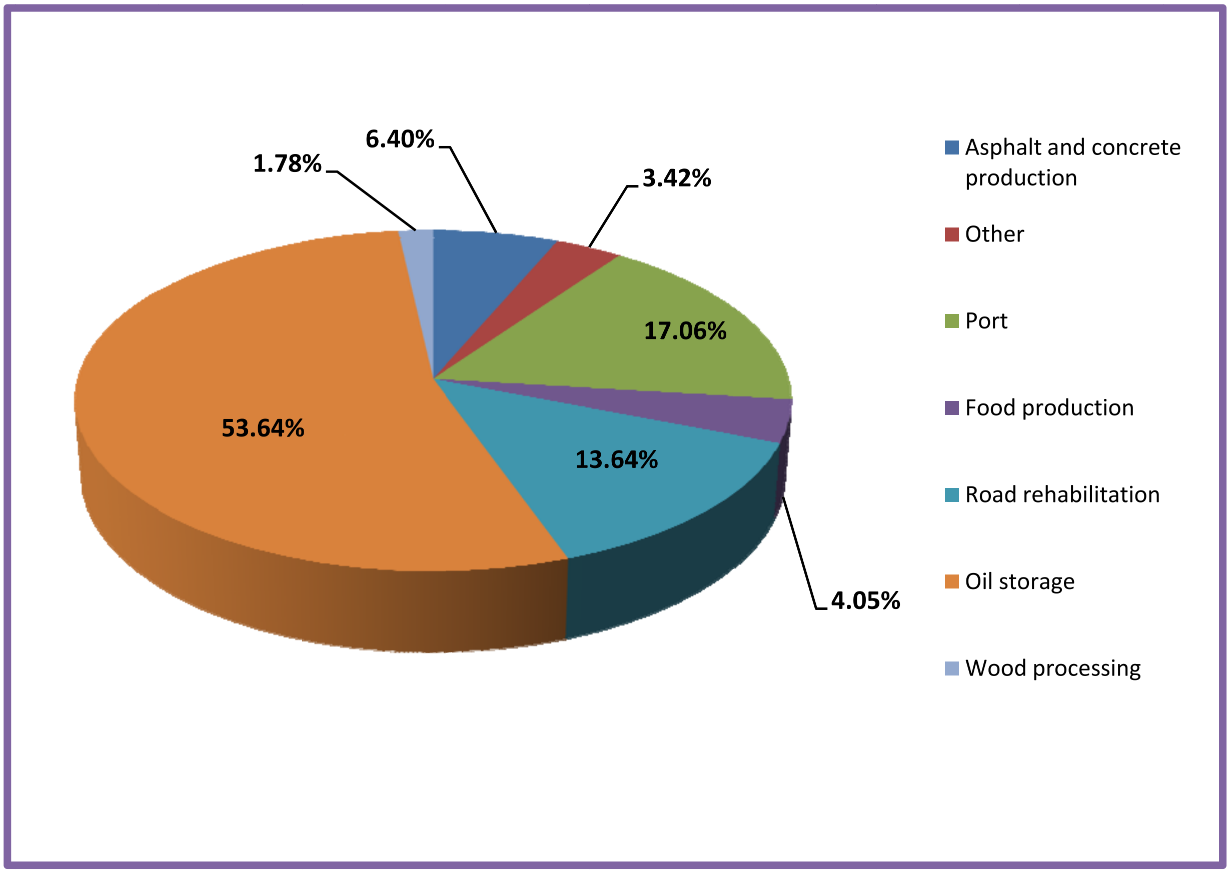
In Adjara, BATUMI oil terminal was the greatest contributor to gross regional emissions (78.46%), followed by fuel stations (12.46%), food production (10.98%), inert materials production (3.45%), asphalt and concrete production (2.99%), construction materials production (1.91%) and wood processing (1.87%).

Figure 45. Sector contribution to 2012 gross emissions of Adjara



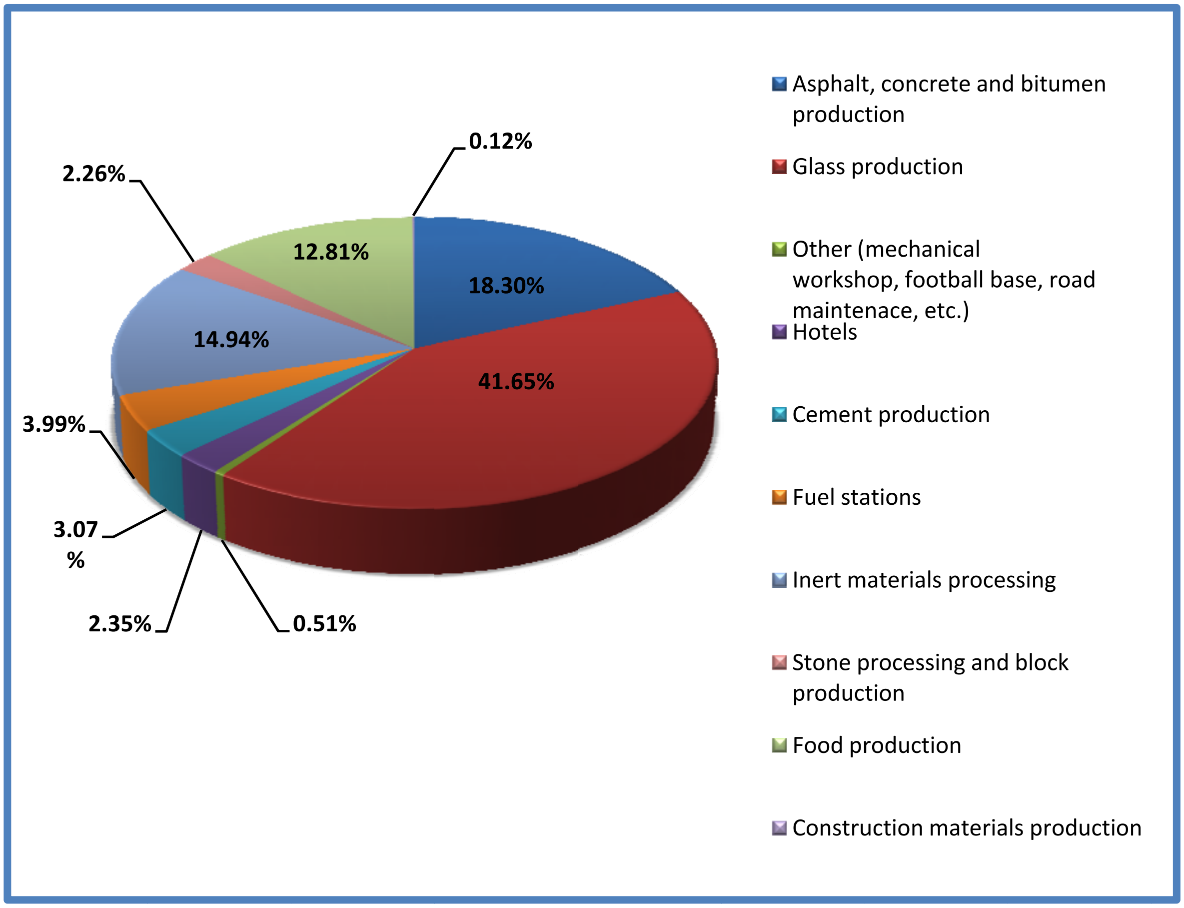
In Samegrelo-Zemo Svaneti, the contributor to gross regional emissions was the oil storage (53.64%), followed by the marine cargo shipment (17.06%), road rehabilitation (13.64%), asphalt and concrete production (6.40%), food production (4.05%) and wood processing (1.78%). Other sectors together made up 3.42%.

Figure 46. Sector contribution to 2012 gross emissions of Samegrelo-Zemo Svaneti



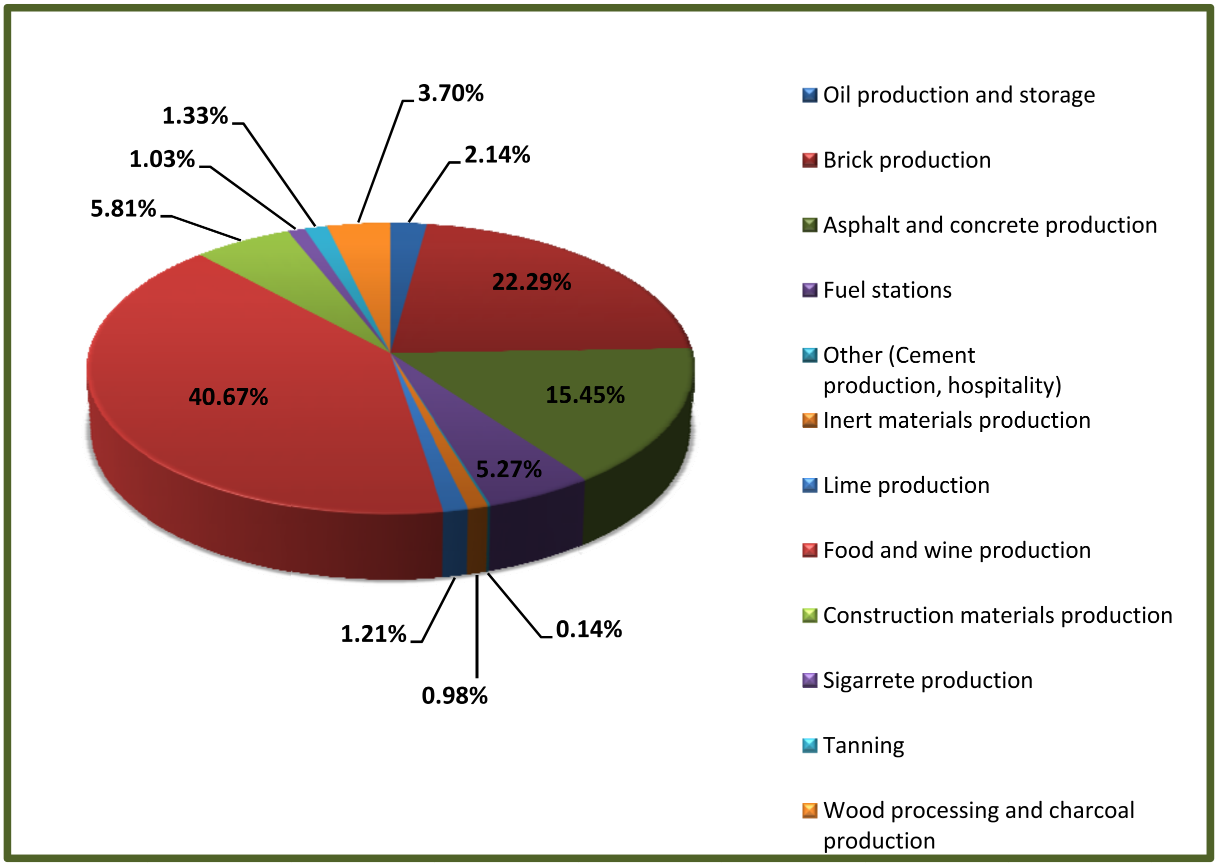
In Mtskheta-Mtianeti, glass production contributed the largest share to gross regional emissions (41.65%), followed by asphalt, concrete and bitumen production (18.30%), inert materials processing (14.94%), food production (12.81%), fuel stations (3.99%), cement production (3.07%), hospitality businesses (2.35%) and stone processing and blocks production (2.26%). Remaining sectors/activities alltogether made up 0.63% of gross regional emissions.

Figure 47. Sector contribution to 2012 gross regional emissions of Mtskheta-Tianeti



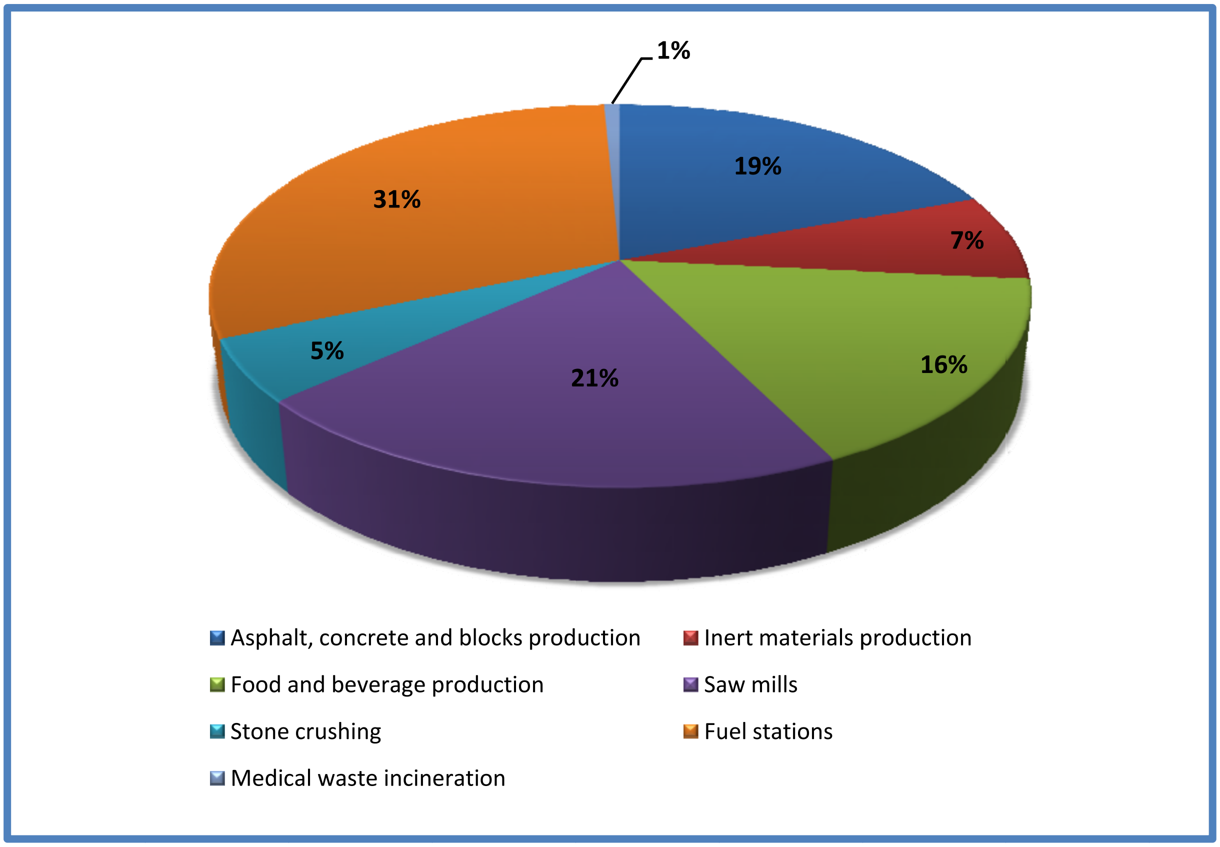
In Kakheti region, food and wine production was the leader among other branches in terms of gross regional emissions, contributing 40.67% to total emissions, followed by brick production (22.29%), asphalt and concrete production (15.45%), construction materials production (5.81%), fuel stations (5.27%), wood processing and charcoal production (3.70%) and oil production and storage (2.14%). Remaining sectors/activities altogether, includingcement production, tanning, Sigarrete production, hospitality businesses, inert materials and lime production made up only 4.69%.

Figure 48. Sector contribution to 2012 gross regional emissions of Kakheti region



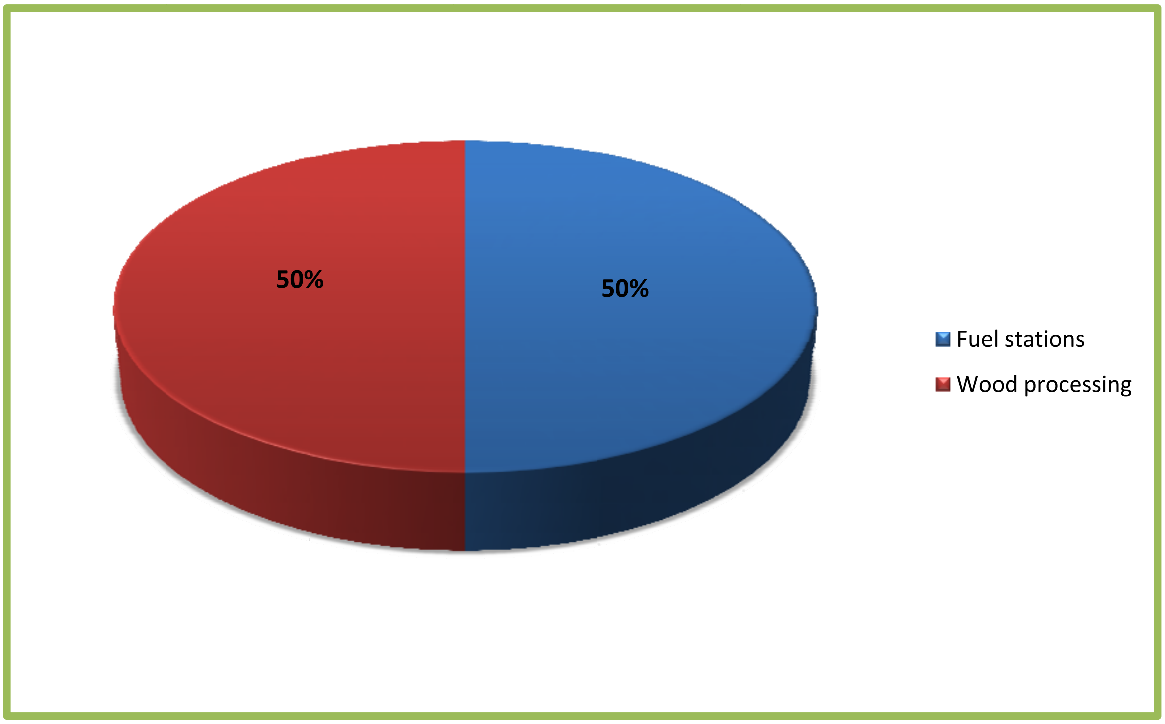
In Samtkkhe-Javakheti region,fuel stations contributed the largest share to gross regional emissions from point and diffused/area sources (31%), followed by saw mills (21%), asphalt, concrete and blocks production (19%), food and beverage production (16%), inert materials production (7%), stone crushing (5%) and medical waste incineration (1%). In terms of emissions of individual substances, dust and VOCs emissions accounted for the greatest share of gross regional emissions due to fugitive emissions of dust from saw mills, inert materials extraction and processing companies, etc. as well as fugitive emissions of VOCs from fuel stations operated at multiple locations.

Figure 49. Sector contribution to 2012 gross regional emissions of Samtskhe-Javakheti region



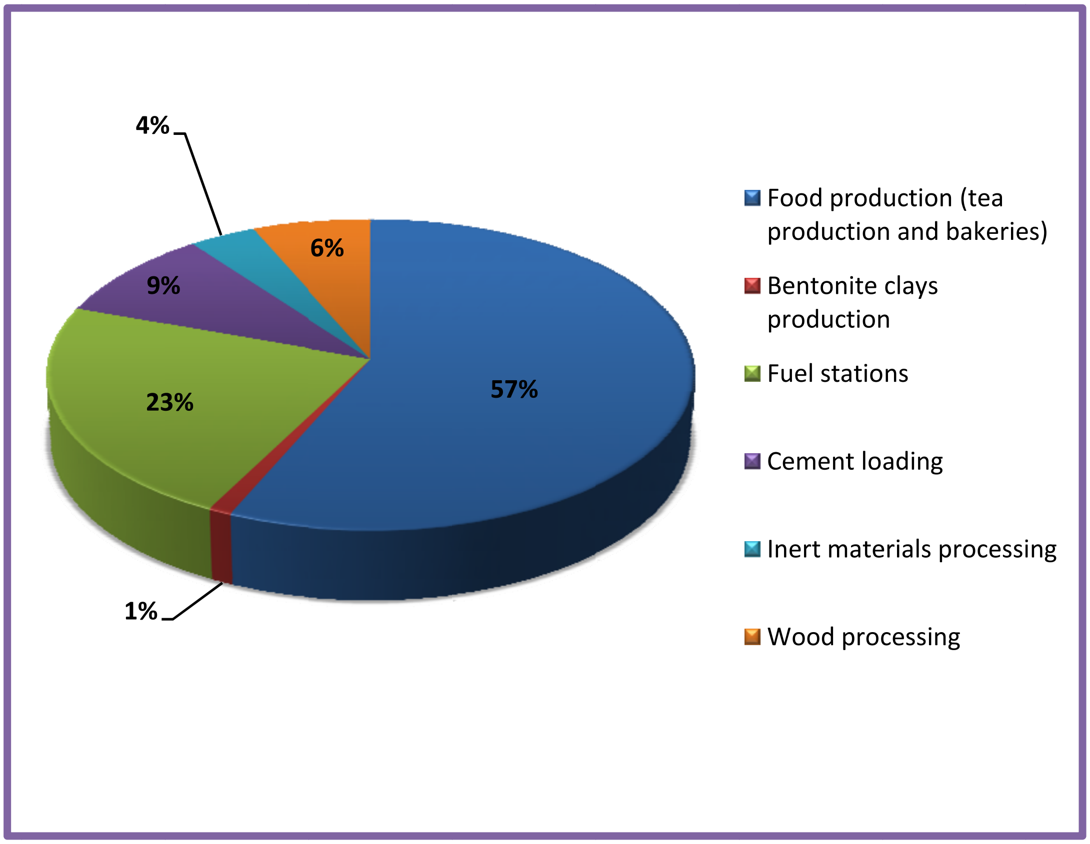
In Racha-Lechkhumi regiononly two types of activities/sectors - wood processing plants and fuel stations were reported to emit 8.877 tons of pollutants into the air (predominantely dust and VOCs), with 50% share of gross regional emissions each.

Figure 50. Sector contribution to 2012 gross regional emissions of Racha-Lechkhumi and Kvemo Svaneti



In Guria region, food production sector (predominantely, tea production) contributed the largest shareto gross regional emissions (57%) followed by fuel stations (23%), cement loading (9%), wood processing (6%), inert materials processing (4%) and bentonite clays production (1%). Among various substances, dust emissions made up the largest share of total emissions, due to coal burning by tea factories and futigive emissions during cement loading, followed by VOCs fugitive emissions from fuel stations located at multiple locations and, CO and SO_2 emissions due to coal burning in team factories.

Figure 51.Sector contribution to 2012 gross regional emissions of Guria region



7.2.2 Contribution of Different Cities to Point and Diffused/Area Source Emissions

In 2012, the largest contributor to total stationary source emissions among various cities of Georgia was Zestaponi with 9,521 tons of gross emissions (36%) of criteria pollutants, followed by Rustavi with 6,550 tons of gross emissions (25%), Kaspi with 3,521 tons of gross emissions (13%), Gardabani with 3,111 tons of gross emissions (12%) and Batumi with 2,015 tons of gross emissions (8%). In terms of individual substances, Zestaponi contributed the largest share of total CO emissions, Rustavi – the largest share of NO_x, dust and SO_2emissions and Batumi – the largest share of VOC emissions.

It should be mentioned that there is significant temporal variation of emissions for individual cities and regions. This might be attributed to: 1) the change of sectoral profile of the Georgia's economy, e.g. increase in the number of SMEs and area/diffused sources such as services and gas stations particularly in Tbilisi and Kutaisi, where trade and transpirationplay significant roles in the local economy; 2) Variations in GDP growth rates between 2004-2008, 2009 (marked with negative GDP growth rate) and 2010-2012 (marked with recovery of the economy); 3) improved/changed reporting.

Figure 52. 2012 pollutants emissions from various cities, tons

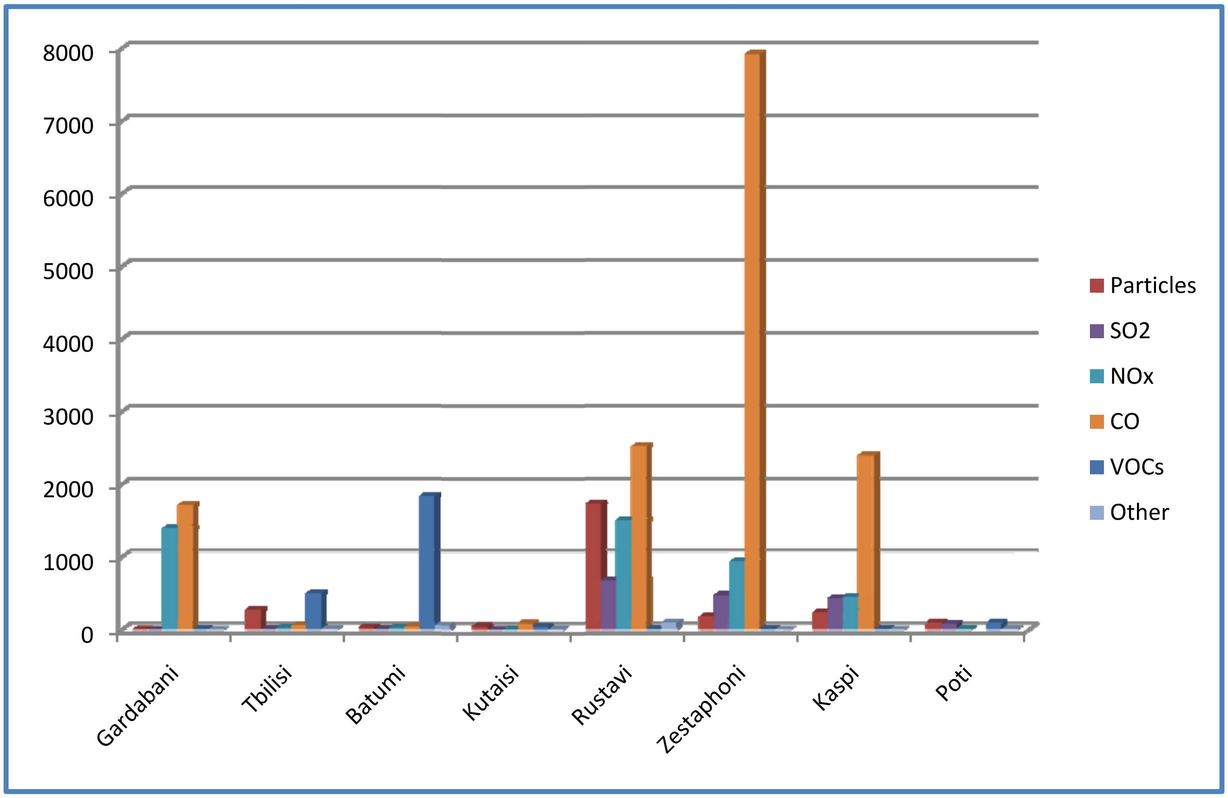


Figure 53. 2004-2012 emissions in Gardabani, tons

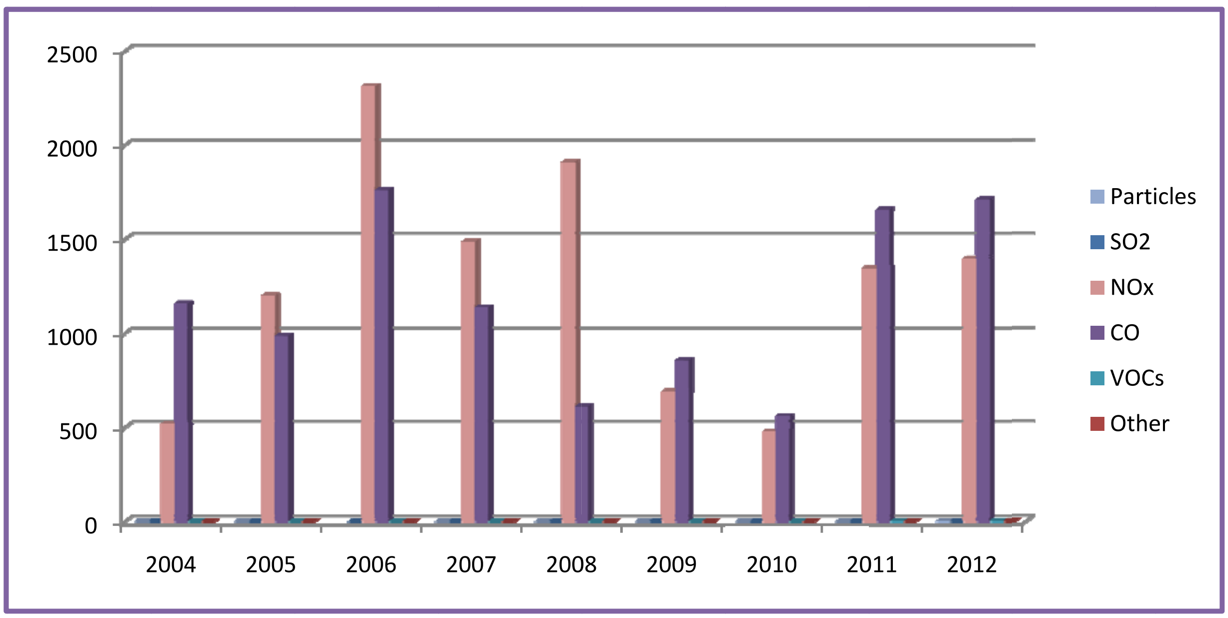


Figure 54. 2004-2012 emissions in Tbilisi, tons

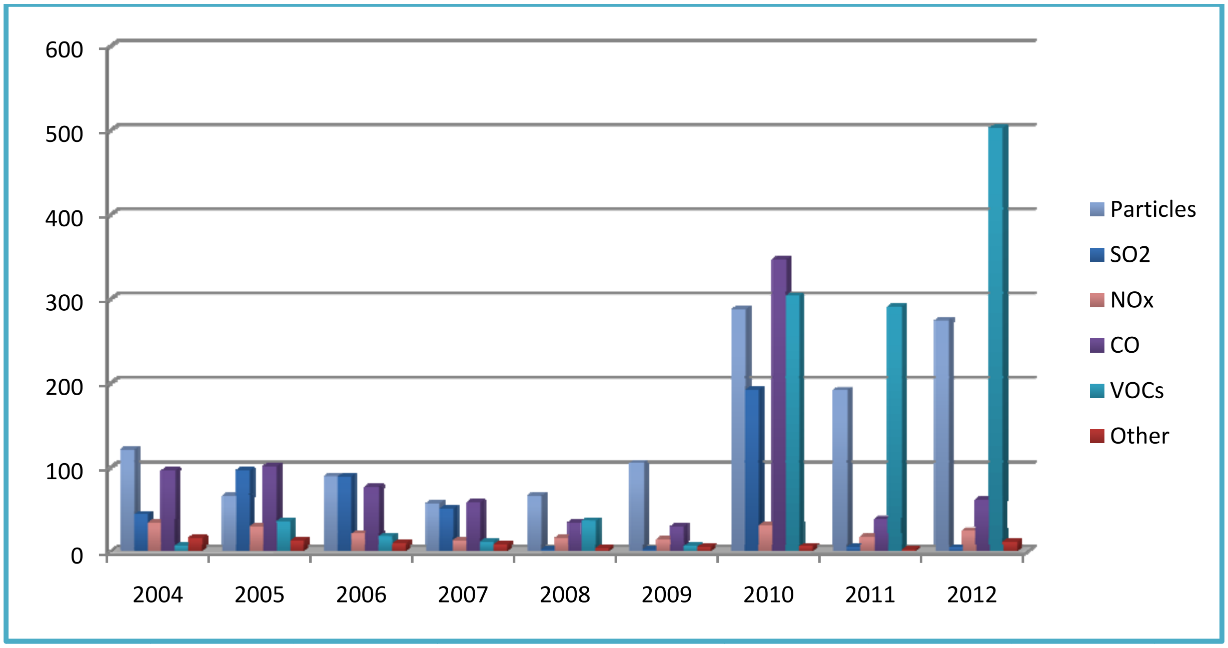


Figure 55. 2004-2012 emissions in Batumi, tons

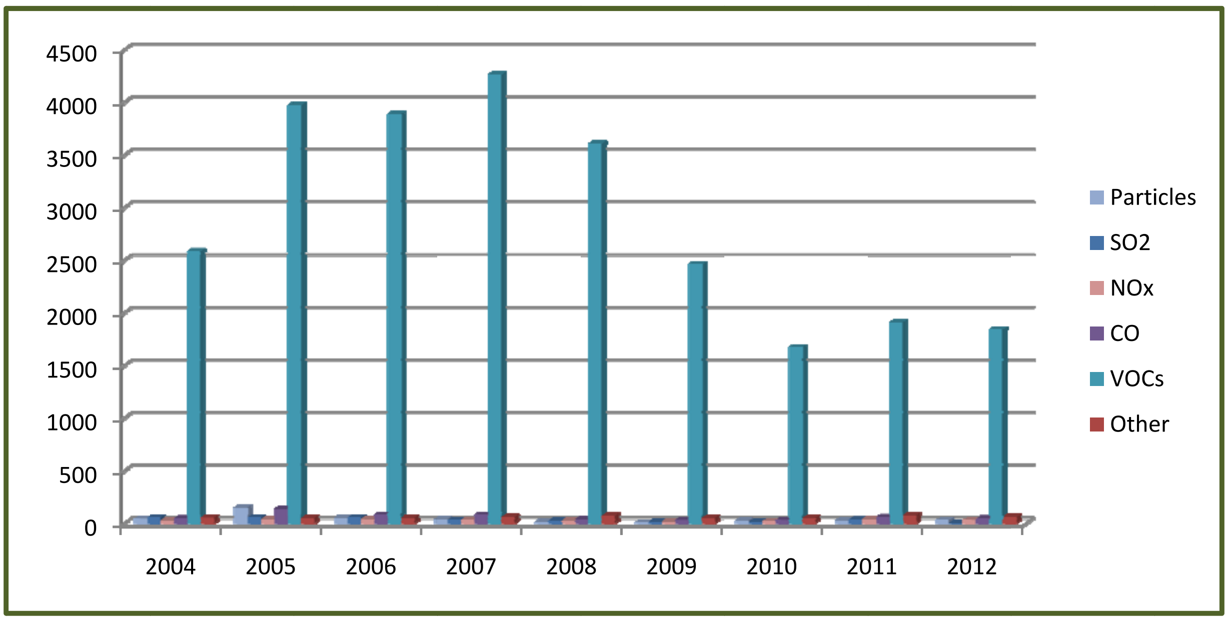


Figure 56. 2004-2012 emissions in Kutaisi, tons

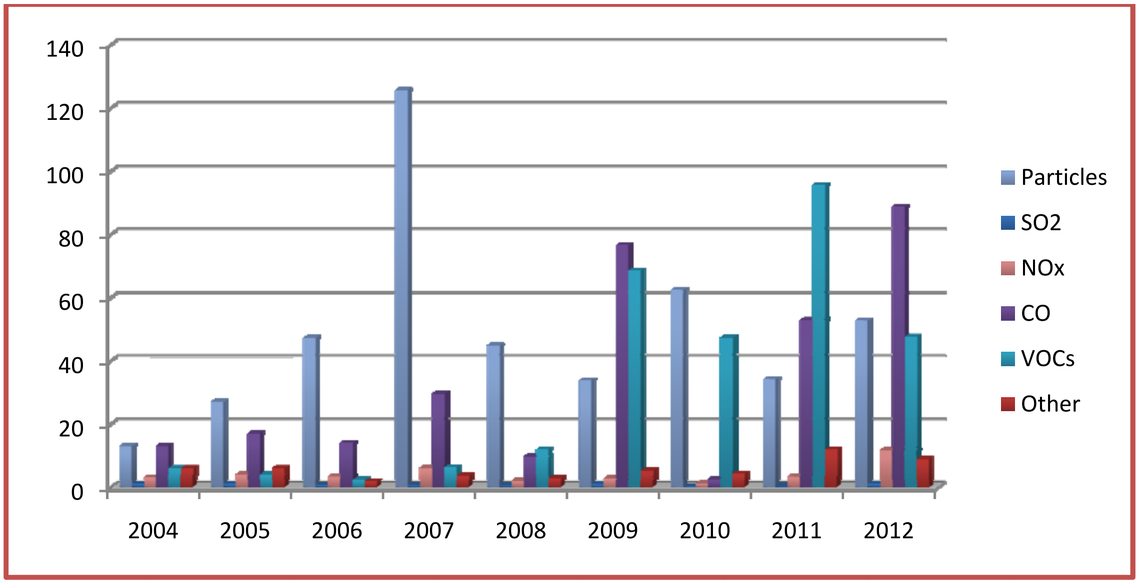


Figure 57. 2004-2012 emissions in Rustavi, tons

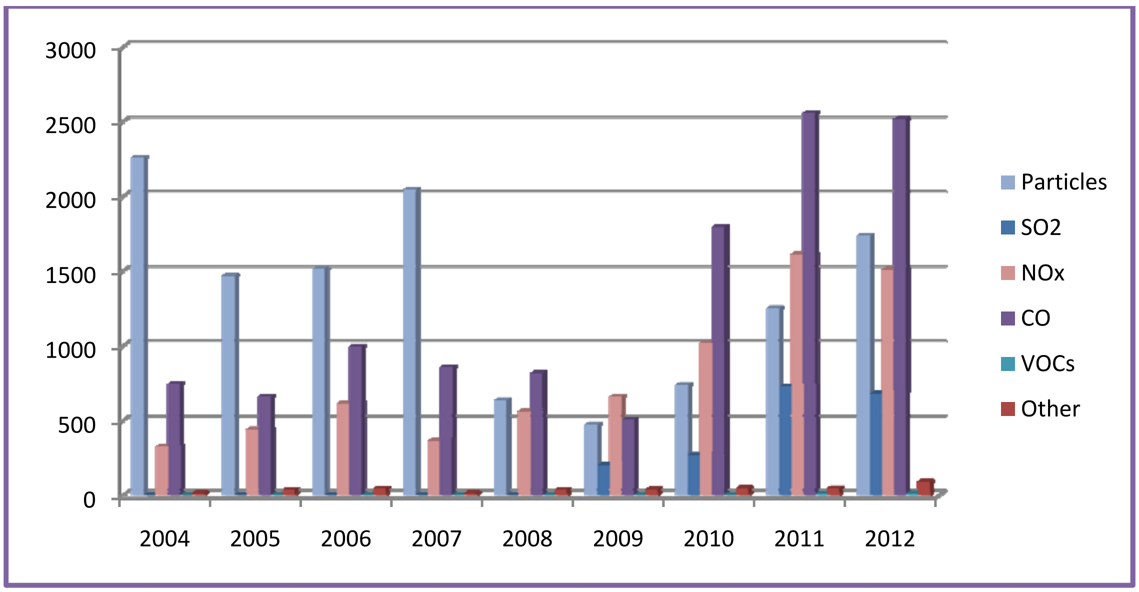


Figure 58. 2004-2012 emissions in Zestaponi, tons

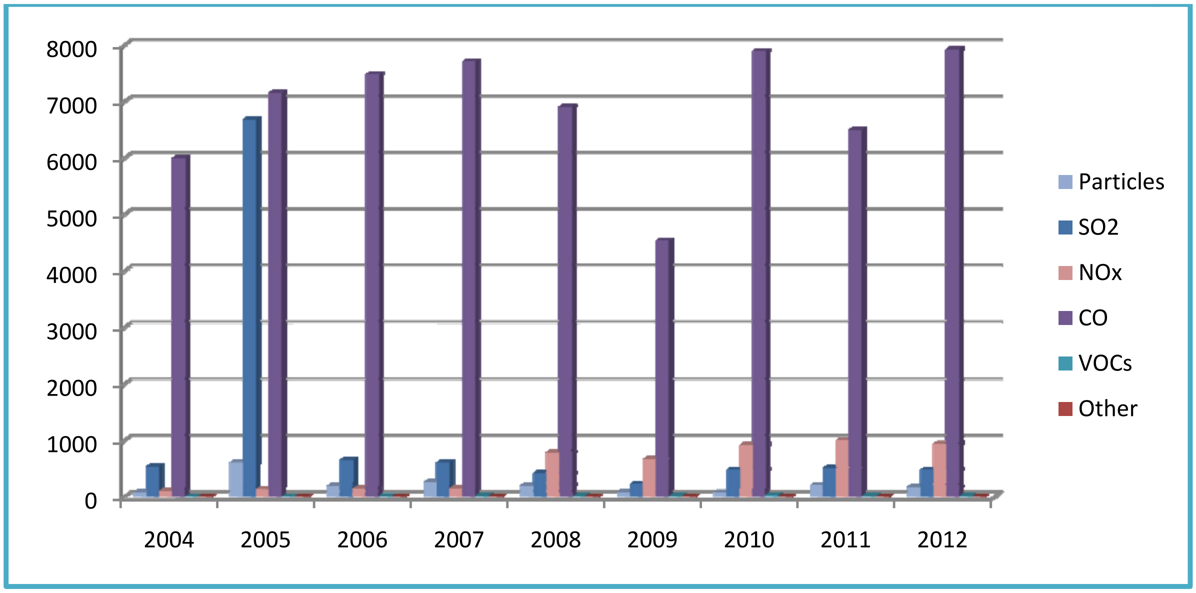


Figure 59. 2004-2012 emissions in Kaspi, tons

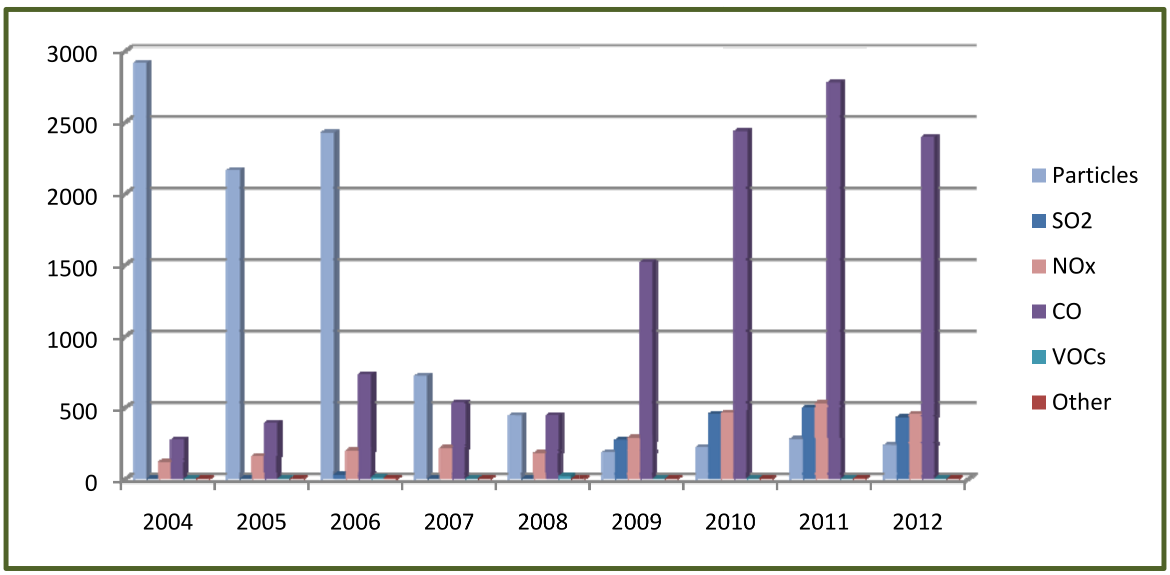
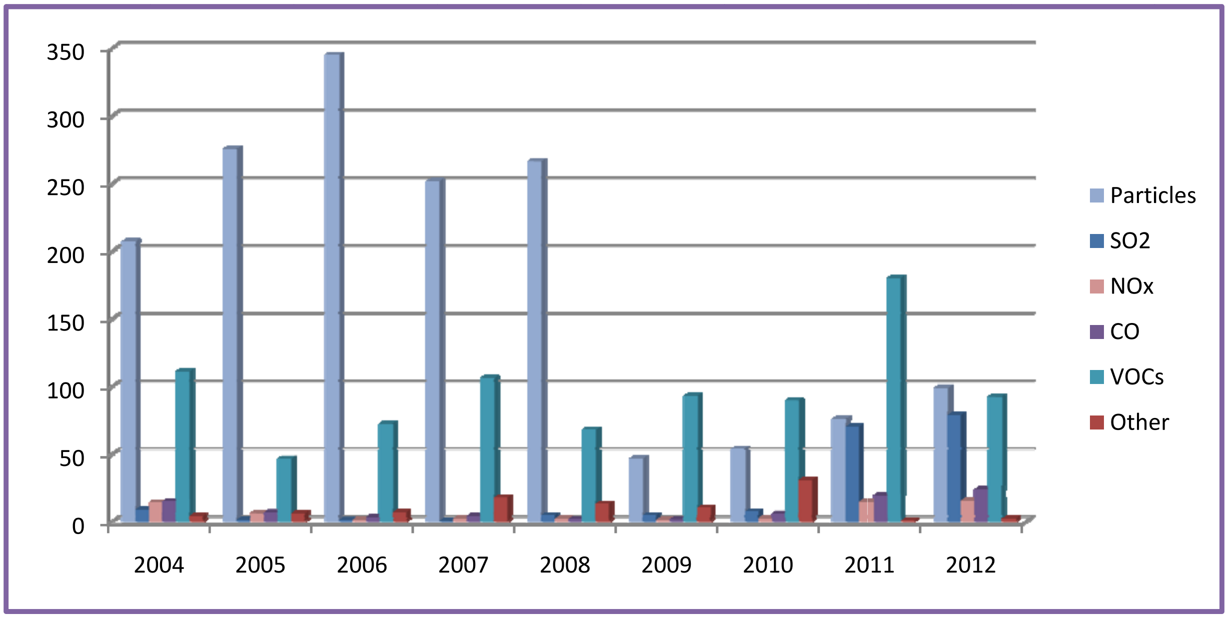


Figure 60. 2004-2012 emissions in Poti, tons



7.2.3Major Point Sources of Emissions

In 2012, large point sources (emitting over 100tons of pollutants into the air)contributes over 86% to gross national point and diffused source emissions from activities subjects to annual reporting to the MoENRP. These facilitiesare concentrated in major cities and some smaller towns, including Tbilisi, Rustavi, Kutaisi, Batumi, Kaspi, Zestaponi, Poti. Below is given the table of major point sources in accordance with 2012 emission inventory report.

Table 5. Major point sources of pollution [17]

Name	Location	Type of Industry	Annual emissions, tons	Dust	SO2	NOX	CO	VOC	Other
KvemoKartli									
KartuliCementi (Georgian cement)	Rustavi	Cement	2060.504	35.642	313.841	661.538	1049.483	0.000	0.000
Mtkvari Energy	Gardabani	Thermal power generation	1704.328	0.000	0.000	828.746	875.582	0.000	0.000
Sakcement/Heidelberg Cement (RustavCement)	Rustavi	Cement	1520.327	155.230	159.825	336.504	868.768	0.000	0.000
Georgian International Energy Corporation (Tbilsresi), 3rd and 4th power units	Gardabani	Thermal power generation	1341.050	0.000	0.000	549.180	791.870	0.000	0.000
Rustavi Steel	Rustavi	Metallurgical	1000.663	652.064	0.057	84.418	263.585	0.426	0.113
Energinvest: Rustavi Azoti (nitrogen plant)	Rustavi	Chemical	816.012	165.306	3.141	357.069	251.049	0.000	39.447

[17] 2012 emission inventory reporting data

IndustriaKiri, ltd	Rustavi	Lime production	307.447	53.089	203.546	6.710	44.102	0.000	0.000
Geosteel	Rustavi	Steel and brass manufacturing	192.601	123.185	0.000	50.874	18.542	0.000	0.000
Rustavi Steel	Rustavi	Dross processing	178.542	178.542	0.000	0.000	0.000	0.000	0.000
Rusmetali (Ferroalloy plant)	Rustavi	Ferroalloy production	149.596	147.739	0.000	1.857	0.000	0.000	0.000
Ltd Kumisi	Gardabani, village Kumisi	Chicken and egg production	142.330	80.047	23.737	1.334	25.190	0.000	12.022
Imereti									
Saknakhshiri (Georgian Coal), JIJ group	Tkibuli	Coal production	7672.524	131.853	59.334	2.150	99.749	7379.438	0.000
Georgian Manganese	Zestaponi	Ferroalloy production	9498.393	163.900	475.594	936.284	7922.615	0.000	0.000
Chiaturmananum-Georgia[18]	Chiatura	Manganese production and processing	46.079	45.157	0.000	0.922	0.000	0.000	0.000
ShidaKartli									
Saqcement/Heidelberg Cement Georgia – Kaspi Cement plant	Kaspi	Cement and Clinker production	3509.510	228.040	430.690	455.190	2395.590	0.000	0.000
Agara Sugar company	Agara	Sugar production	219.471	8.280	0.000	60.823	150.368	0.000	0.000
Adjara									
Batumi oil terminal	Batumi	Oil storage and Transportation	1852.763	0.157	1.152	17.720	23.042	1757.243	53.449
Samegrelo-ZemoSvaneti									
Black Sea terminal	v. Kulevi, Khobi municipality	Oil storage and transportation	651.451	0.230	1.314	6.138	0.429	639.930	3.410
Poti sea port	Poti	Sea port	225.238	97.556	73.312	13.497	14.732	25.859	0.282
Kakheti									
Nasadgomari, ltd	Sagarejo	Brick production	187.700	43.700	19.000	2.000	123.000	0.000	0.000
Mtskheta-Mtianeti									
JSC Mina (Glass)	Ksani	Glass production	147.120	64.820	0.000	23.700	58.600	0.000	0.000
Tbilisi									
#1 Road company	KvemoPhonichala, Tbilisi	Asphalt-concrete production	95.651	75.947	1.531	5.234	12.939	0.000	0.000
TOTAL			***33519.3***	***2450.484***	***1766.074***	***1401.888***	***14989.24***	***9802.896***	***108.723***

The largest point source of air pollution, in terms of both gross emissions and emissions ofhazardous/toxic substances is Zestaponi ferroalloy plant releasing significant amount of

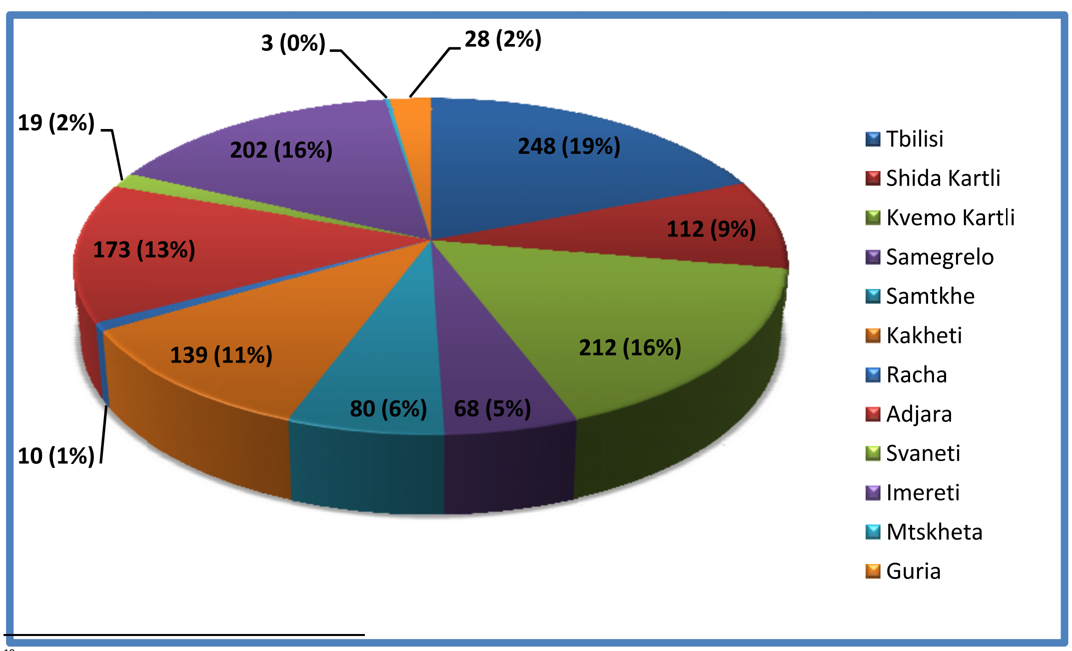
[18] This activity is included in the list due to the toxicity of emissions (manganese bearing dust)

dust containing manganese. Other significant sources of pollution are coal and manganese production and enrichment plants in Tkibuli and Chiatura, Batumi oil terminal, Rustavi steel and nitrogen production plants, Gardabani thermal power generation plant and cement production plants in Rustavi and Kaspi. These industries emit significant amounts of NO_X, SO_2, VOCs and dust. Cement and concrete industries are characterised with high dust emissions though, the Heidelberg Cement has recently installed high efficiency filters and reduced its emissions by about 75%.[19] Large stationary sources contributed over 85% tons of the total stationary source emissions in Georgia in 2012.

7.2.4 Small Point and Diffused (area-based) Sourcesof Pollution

Official emission reporting data from 2012 indicate operations of a numerous medium to small size industrial facilitiesacross the country, emitting less than 100 tons of pollutants into the air, including construction materials production industries (e.g. asphalt, concrete, blocks, chalk powder, lime, brick, cement, metaloplastics production industries, etc.), food industries (beverage production, canned food production, sunflower oil production, chicken and egg production, wine production, tea and tobacco production, chocolate production, etc.), light industries (textile production, tanneries, etc.) and chemical industriesas well as on a numerous diffused/area sources, predominantly, fuel stations concentrated in cities and towns. Widespread activities are also inert materials extraction and processing, stone processing, wood cutting and processing activities with associated fugitive emissions of dust, road maintenance and rehabilitation activities, small bakeries and hospitality businesses. Diffused/area sources make up only about 17% (837.155 t) of gross emissions from small point and area sources (5,056.87 t). Of this amountup to 57% is attributed to fugitive emissions from Tbilisi fuel stations. Altogether small point and area sources contribute about 15% to gross national point and diffused source emissionssubject to annual reporting to the MoENRM. The largest number of small and area sources is attributed to Tbilisi, followed by KvemoKartli, Imereti, Adjara, Kakheti and ShidaKartli.

Figure 61. Number of small point and area sources



[19] Source: Phdthesis by Ms. KetiKordzakhia. Study of Georgia's Ambient Air Quality and Selected Methods for Combating Air pollution, საქართველოსატმოსფერულიჰაერისხარისხობრივიმდგომარეობისშესწავლადამისიდაბინძურებისგანდაცვისზოგიერთიმეთოდი. 2009http://sangu.ge/images/disertacia_kordzakhia.pdf

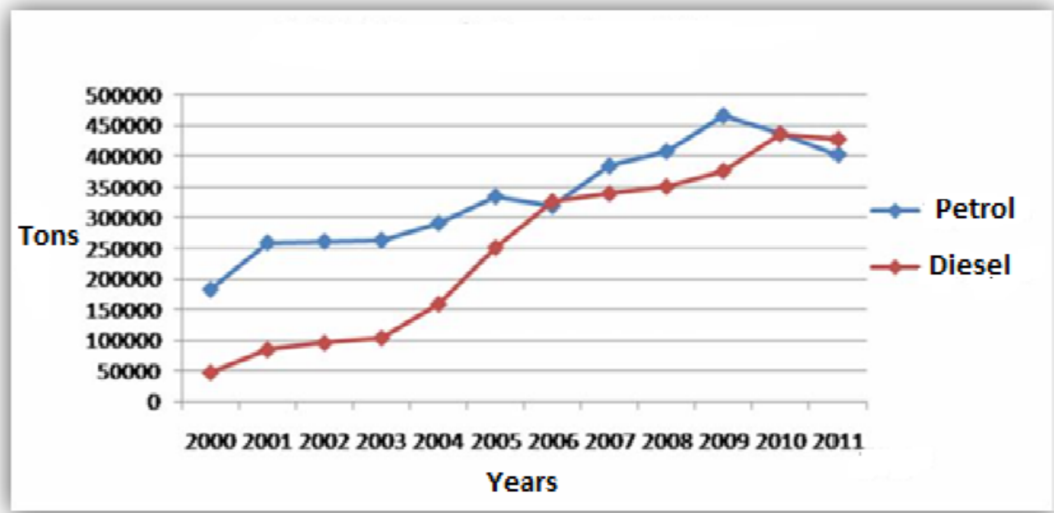
Annual emission inventories data do not include emissions from residential and municipal gas and biomass burning since these activities are not subject to annual reporting.

7.4 Emissions from the Transport

7.4.1 Characteristics of Georgian Transport Sector and Air Pollution from it

As we can see from figures of gross emissions and emissions of individual substances by sectors for the period of 2000-2012 discussed in previous parts, transport is a major contributor to the total national emissions (53%), the largest contributor to total CO (80% in 2012)and NO_x emissions (63% in 2012) and one of the major contributors to emissions of SO_2, VOCs and ozone and $PM_{2.5}$ precursors in Georgia. The trend of increased use of diesel fuel is alarming as this is a source of SO_2 and soot emissions, carrying also carcinogenic substances, like benzo(a)pyrene.

Figure 62. Trend of the use of petrol and diesel fuels in Georgia



Car fleet is steadily growing in urban areas of Georgia and particularly in Tbilisi, where about 38% of the country's vehiclesis concentrated. In 2000, 70 cars per 1,000 inhabitants were recorded in Georgia, while this figure has doubled during the last decade and reached 12 passenger cars per 100 persons in 2011.[20]

[20] Source: Phdthesis by Ms. KetiKordzakhia. Study of Georgia's Ambient Air Quality and Selected Methods for Combating Air pollution, საქართველოსატმოსფერულიჰაერისხარისხობრივიმდგომარეობისშესწავლადამისიდაბინძურებისგანდაცვისზოგიერთიმეთოდი. 2009http://sangu.ge/images/disertacia_kordzakhia.pdf

Figure 63. Dynamics of car fleet size of Georgia

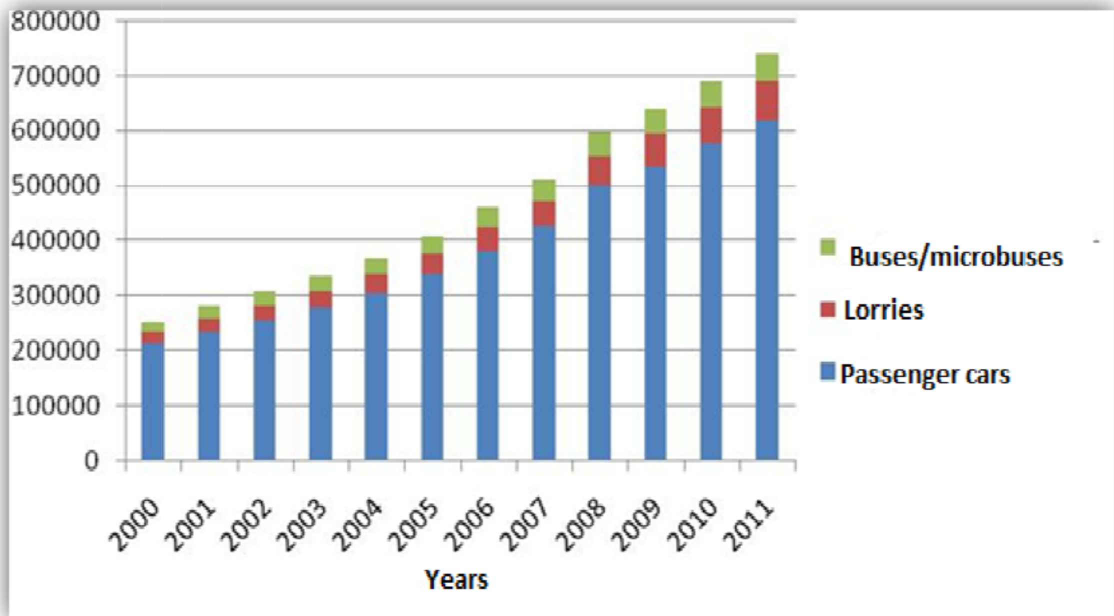
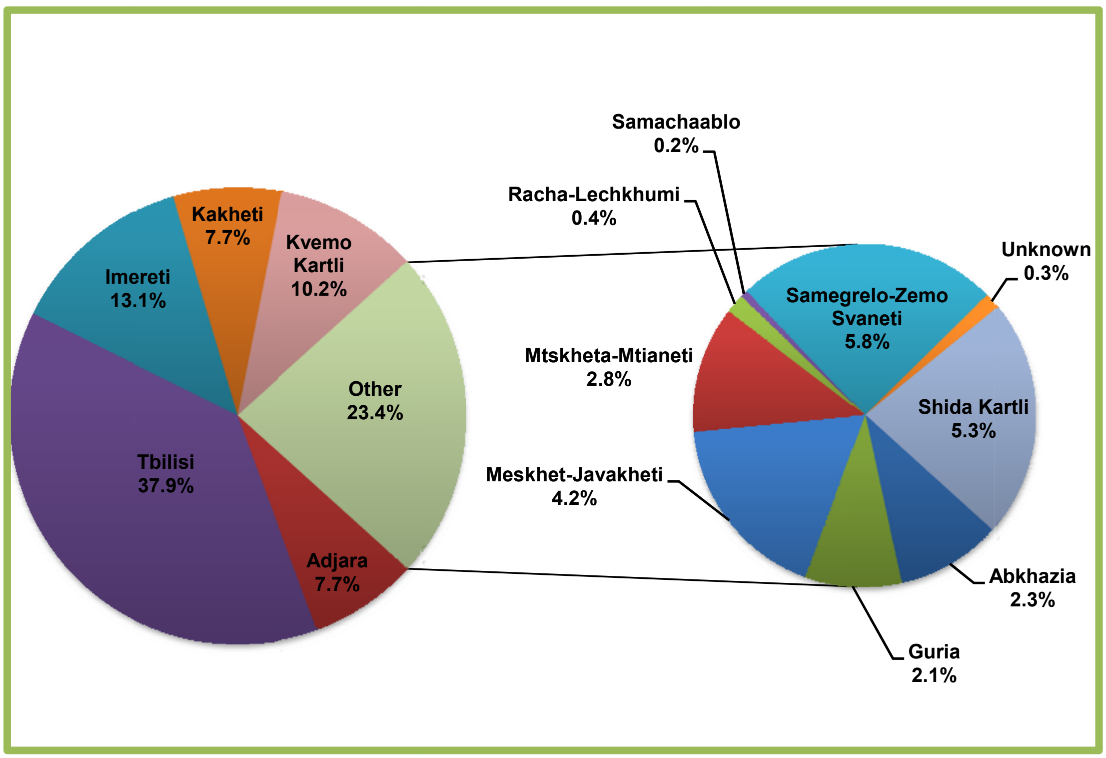
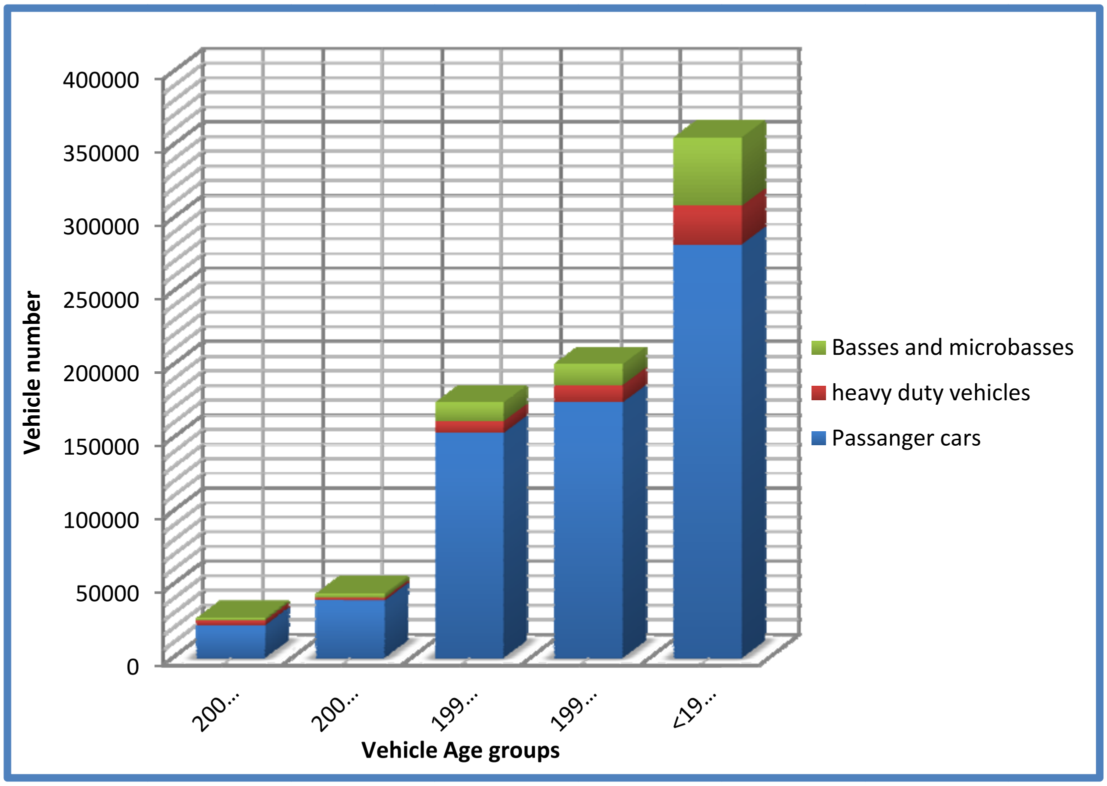


Figure 64.Distribution of the car fleet per regions



The age of the majority of cars is more than 15-20 years and they are not maintained properly due to the absence of mandatory vehicle inspection service. Most of these cars do not have catalytic converters. Furthermore, fuel quality is not tested in the distribution networks and in vehicles therefore; there is no information on the real quality of fuel.

Figure 65. 2012 data on Georgia's car fleet



Routine ambient air monitoring data, though scarce, and air quality study for Tbilisi from2002indicate on high content of NO_x, SO_2, TSP and benzene in the ambient air. In addition, studies performed in2002 have showed high level of ground-level ozone in the suburbs of Tbilisi. Ozone levels measured at 2 monitoring sites inTbilisi frequently exceed Georgian MACs for summer-fall periods, when unfavourable climate conditions occur in the form of temperature inversions and the city is covered with sick blanket of smog. Furthermore, urban air quality was recently modelled for Tbilisi to test and calibrate ADMS-Urban software that also showed exceedances of EU NO_x annuallimit value of 40 $\mu g/m^3$across the majority of central area of the city. Likewise, PM_{10} concentrations exceeded annuallimit value of 40 $\mu g/m^3$ along the major roads; SO_2 concentrations were likely to exceed 24-hour mean Georgian MAC of 50 $\mu g/m^3$ along major roads. More detailed discussion of monitoring data and above studies for Tbilisi is provided in the reports 1 and 3.

7.4.2 Detailed Characteristics of Typical Urban Car Fleet for Selected Major Cities

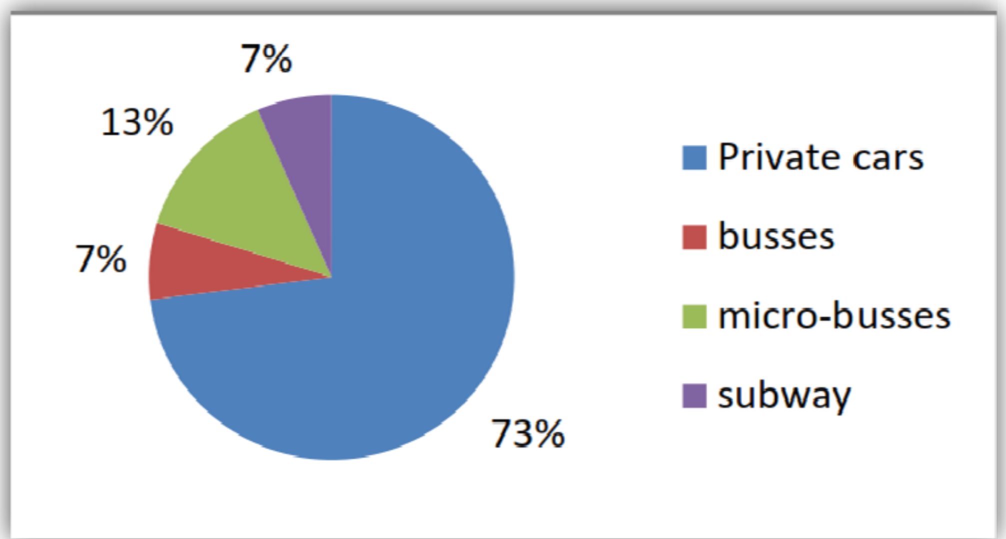
Detailed information on the car fleet, road intensity and other parameters of urban transport does not exist for the majority of Georgian cities. The most complete information exists on the city of Tbilisi, collected under the Covenant of Mayors SEAP initiative and Emission Inventory and Preliminary Modelling Study developed in 2013. Furthermore, 2009-2011 information on the car fleet and total distance travelled annually for Rustavi and Batumi can be found in Rustavi and Batumi SEAPs.

Tbilisi car fleet is composed of public ground transport and private vehicles. Public ground transport is divided into busses and micro-busses. Detailed study of Tbilisi transport, conducted in 2009 under the Covenant of Mayors' SEAP initiative[21] showed that the city

[21] Source: Sustainable Energy Action Plan. City of Tbilisi. 2011-2020. http://mycovenant.eumayors.eu/docs/seap/1537_1520_1303144302.pdf

commuters travelled 7,544 million passenger-kilometres in total, with 73% travelled by private cars and 27% - by public transport. Of the mobility provided by public transport, 50.3% was accounted for minibuses, 25.1% for busses and 24.6% for subway.

Figure 66. Split of transport modes in Tbilisi in 2009



Accordingto the SEAPBaseline Emission Inventoryfor2009, the bus fleet was composed of three different types of diesel-runningbusses including240 vehicles with fuel consumptionof 55 litres per100km, 150 vehicles with fuel consumption of 38litres per100km and 544 vehicleswith fuel consumption of 24 litres per100km. Intotalthe busses have covered 58.4 million vehicle-kmand served 56.9millionpeople, including4 lines (88, 61, 51 and21).In2010, the city government decided tooptimize the bus fleet and reducedthe numberof buslinesfrom 125 to 92 that automatically resultedinadecrease of buses runninginthe city. The quality of the existingbus network services sufferthe lack of regularityof bus lines,lack of information forpassengers onroutes and time schedules,longwaitingintervals, lack of route connections andovercrowded buses.

The minibus fleet of 2009 was composed of 2,621 vehicles. Tbilisi mini-buses have diesel-fuel engines with average fuel consumption of 12 litres per 100 km. On average minibuses travel 220 km daily and the passenger turnover is approximately twice as much as for bus network. Total distance travelled by minibuses is 210 million vehicle-km annually. The vehicles used by minibus companies are more than 20 year-old obsolete cars.

In 2009, the passenger car fleet of Tbilisi, including taxis consisted of 233,187 cars. There is no official statistics on the mobility of passenger cars. A survey conducted under the SEAP showed the average car occupancy is about 1.85 people per car. Average distance travelled is 35 km per day (12775 km per annum). Annual average distance travelled by private cars is 2,978 million vehicle-km. There is also a municipal service car fleet, composed of about 176 vehicles travelling about 33,600 km/y distance or 6 million vehicle-km. Altogether, private and municipal passenger cars travel 2,984 million vehicle-km.[22]

[22] Source: Compilation of Emissions Inventory and Preliminary Air Quality Modelling for Tbilisi. Cambridge Environmental Research Consultants. 2013. Air Quality Monitoring in Tbilisi. Georgia. PSOM10/GE/11/

Since there are no restrictions on the age of vehicles on the road, the number of second-handEuropean cars is gradually increasing. By 2009, 41% of vehicles were 20 years old or older.The catalytic converters are often destroyed or removed from imported cars.The share of Soviet-made cars is still high but it is gradually decreasing.

In accordance with SEAP and emission inventory and preliminary modelling studies, there were 15,170 commercial goods vehicles in Tbilisi in 2009, with an average fuel consumption rate of 24 l per 100 km and annual travel distance of 504 million vehicle-km.

Table 6.Distance travelled by different types of vehicles

Vehicle type	Estimate annual mileage (million vehicle-km)	Tbilisi fleet breakdown (%)
Cars	2,984	79.4
Mini-buses	210	5.6
Buses	58	1.6
Good vehicles	505	13.5

Car fleet of Rustavi, in accordancewith 2011 SEAP[23]consisted of following categories of registered vehicles:i) public transport (buses, mini-buses), ii) municipal service cars, including fire engines and; iii) private (light) vehicles. In total 2,140 vehicles were registered in 2011, of which 2080 (97%) were private cars. Below is given the statistics of Rustavi car fleet:

Table 7. Rustavi car fleet characteristics

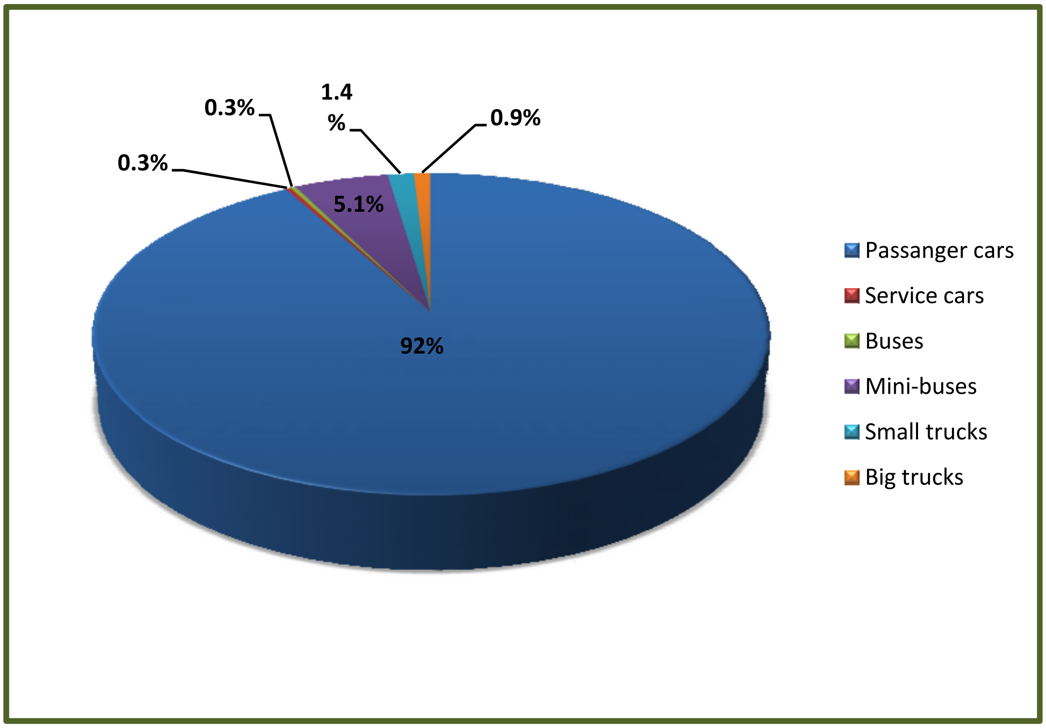
Type	Quantity				Fuel type			Expected mileage annual)	Expected fuel consumed
		0-6	6-12	Older than12	Petrol	Diesel	Gas	km	(litres/per100km)
a) Public transport									
Buses	8			8	-	8	-	63600	40
Route mini-buses	25	18	6		-	24	1	1380000	19
Operating on diesel	24							1380000	19
operating on gas	1			1				42224	
2)Municipal transport	27	16	5	6	22	5			14
Fire engines	5			5	4	1			39 diesel 47petrol

[23] Source: Sustainable Energy Action Plan City of Rustavi. Covenant of Mayors. 2012.http://mycovenant.eumayors.eu/docs/seap/2891_1354173170.pdf

3) Private (light)vehicles	2080				1664	208	208		14

Car fleet of Batumi, in accordance with 2012 Batumi SEAP[24], consists of: i) private cars; ii) municipal service cars; iii) public transport (buses, mini-buses and taxis) and;iv)commercial transport and trucks. Of total amount of vehiclesprivate passenger cars amountedto 30,970,municipal service cars – to 93, buses – to 97, minibuses – to1,725, small trucks - to 475 and, big trucks - to 310.

Figure 67. Percentage share of car fleet by different types of vehicles, 2012



[24] Source: Batumi Sustainable Energy Action Plan. 2014. http://mycovenant.eumayors.eu/docs/seap/3280_1396512547.pdf

Table 8. Number of passenger cars of Batumi by ownership and fuel type

Vehicles	Cars(except for taxi and municipal transport)				Service cars of Batumi municipality			
Fuel Type	2009	2010	2011	2012	2009	2010	2011	2012
Gasolinevehicles	15400	16355	18200	24700	40	45	60	78
Diesel vehicles	1500	1700	2100	4800	4	3	2	15
Electricvehicles	1	3	15	25	0	0	0	0
Natural Gas vehicles	68	102	356	1450	0	0	0	0
Total	16969	18160	20665	30970	44	48	62	93

Table 9. Number of public transport of Batumi by transport and fuel type

Vehicles	Taxi				Buses				Minibuses			
Fuel Type	2009	2010	2011	2012	2009	2010	2011	2012	2009	2010	2011	2012
Gasoline		458	360	650	120	118	85	85	120	118	85	110
Diesel vehicles	210	260	420	510	0	0	0	0	800	1100	1568	1600
Electricvehicles	0	0	0	25	0	0	0	0	0	0	0	0
Naturalgas	5	4	17	100	11	5	3	12	11	5	3	15
Total	545	722	797	1285	131	123	88	97	931	1223	1656	1725

Table 10. Heavy duty (goods) vehicles in Batumi by vehicle and fuel use type, 2009-2012

Vehicles	Small Trucks(up to 2				BigTrucks			
Fuel Type	2009	2010	2011	2012	2009	2010	2011	2012
Gasoline vehicles	15	12	25	50	2	3	0	0
DieselVehicles	150	241	305	425	95	158	230	310
Total	165	253	330	475	97	161	230	310

Table 11.Batumi transport characteristics

Vehicles	Cars (Except for Taxis and Municipal Cars)	Taxi	MunicipalServiceCars of Adjaraand other Government Structures	Buses	Minibuses	Small Trucks(up to 2-ton-cargo)	BigTrucks
Annualmileage (km/car)	7000	15000	5000	103680	61200	21600	43200
Number ofpassengerscarried (passenger)	9894402	950279	92405	65826000	31000320		
Annualpassenger-turnover(passenger-km)	288586725	24746850	641700	460782000	217002240		
Volumeof freight transported (t)						2334420	12519360
Freight turnover (t-km)						43186770	231608160
The averagefuelconsumption for 1gasoline runningcar(L/100 km)	15	14	12	20	13.5	14	30
The averagefuelconsumption for 1diesel runningcar (L/100 km)	12	9	10	25	13.5	14	35
The averagefuelconsumption on electric energy (kWh/100 km)	30						
The averagefuelconsumption on naturalgas(m^3/100 km)	7	6.5					

8. SPATIAL DISTRIBUTION OF AIR POLLUTION BASED ON AIR QUALITY MONITORING AND OTHER ASSESSMENT METHODS AND DETERMINATION OF ANY POSSIBLE EXCEEDANCE OF THE LIMIT VALUES (MAPPING OF AIR POLLUTION)

8.1 INTRODUCTION

Data from a combination of air quality monitoring results and supplementary data in the form of modelling outputs for 4 cities in two zones and one agglomeration have been analysed to determine the spatial distribution of air pollutants across the urban areas of Georgia.

8.1.1 Monitoring

Monthly data from five existing air quality monitoring stations located at Batumi, Zestaponi, Rustavi, Kutaisi and Tbilisi was assessed against air quality model outputs from the same cities.

Information on the monitoring stations has been touched upon previously in section 6 of this report.

8.1.2 Supplementary assessment data

The supplementary data provided for the preliminary assessment provides preliminary information for assessment of air quality with regards to limit values in selected locations of Georgia. The supplementary data consists of a modelling methodology (the ADMS-Urban model) developed to provide a more comprehensive geographical representation of sulphur dioxide concentrations throughout the country.

8.2 AQ Model Results

For the development of the ADMS-Urban AQ model the following data was used: point source pollutant data distributed by the MoENRP[25] (2013), natural gas usage for 4 cities[26] (2013),traffic flow data (2013 estimation[27]), vehicle emissions factors, and background data[28] (2012) were also used.

8.2.1 Model Area

The ADMS Model has been run over distinct separate area grids for each respective city.

Within each model a number of receptors were used for computing the concentrations field.

Details of city model grid receptors are is presented in the Table below

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[25]Excel spreadsheet with annual emission quantities and X-Y coordinates
[26]Provided by gas companies in Georgia, SOCAR.
[27]*World experience for Georgia, 2009, E-60 highway Reconstruction project – Environmental and Social Impact Assessment*
[28]See 8.2.2

Table 12. Model Grid Receptors

Model	Number of Receptors	X spacing, Y spacing (metres)
Zestaponi	7100	1,000
Kutaisi	8100	1,000
Tbilisi	6,375	1,000
Chiatura	7,000	1,000
Rustavi	8100	1,000

8.2.2 Background Air Quality Data

Background concentrations of pollutants were derived taken from the outputs of a preliminary study based upon EMEP/MSC-W modelled concentrations[29]. Below is a summary of background concentrations of pollutants used in each model run.

Table 13. Modelled values of background concentrations

Substance	Annual average concentration (µg/m^3)	Annual average concentration (ppb)
NO_x	3.46	
NO_2	2.43	
O_3		40
SO_2	0.7	
PM_{10}	10.8	

8.2.3 Urban Background concentrations obtained with the ADMS-Urban Model

The ADMS-Urban model was run for four major conurbations in Georgia, for the pollutants NO_2, SO_2, NO_x and PM_{10}. A single hourly meteorological dataset was used and model outputs were generated for annual averages and where appropriate 24 hourly averages and hourly averages only. Accordingly comparisons were made with the limit values and upper assessment thresholds for the various pollutants (Table 16).

A series of geographical distributions of annual mean concentrations were derived and validated against the annual monitoring data gathered from the local monitoring station, where available.

[29] With input from international experts.

8.3 Concentrations and geographical distribution of Sulphur Dioxide in Georgia

8.3.1 Monitoring Results for SO_2

Sulphur dioxide is continuously monitored in 4 cities within Georgia.Monitoring is performed using non-reference methods (with exception of the new Tbilisi station from 2013).

Figures 70 to 73 contain monthly (for 2013/2014) and annual (2008 to 2013) concentrations of monitored SO_2concentrations for the cities of Batumi, Zestaponi, Kutaisi and Tbilisi.

Figure 68. 2013 February-2014 February average monthly concentrations (µg/m^3) of SO_2 measured at Batumi ambient air quality monitoring site

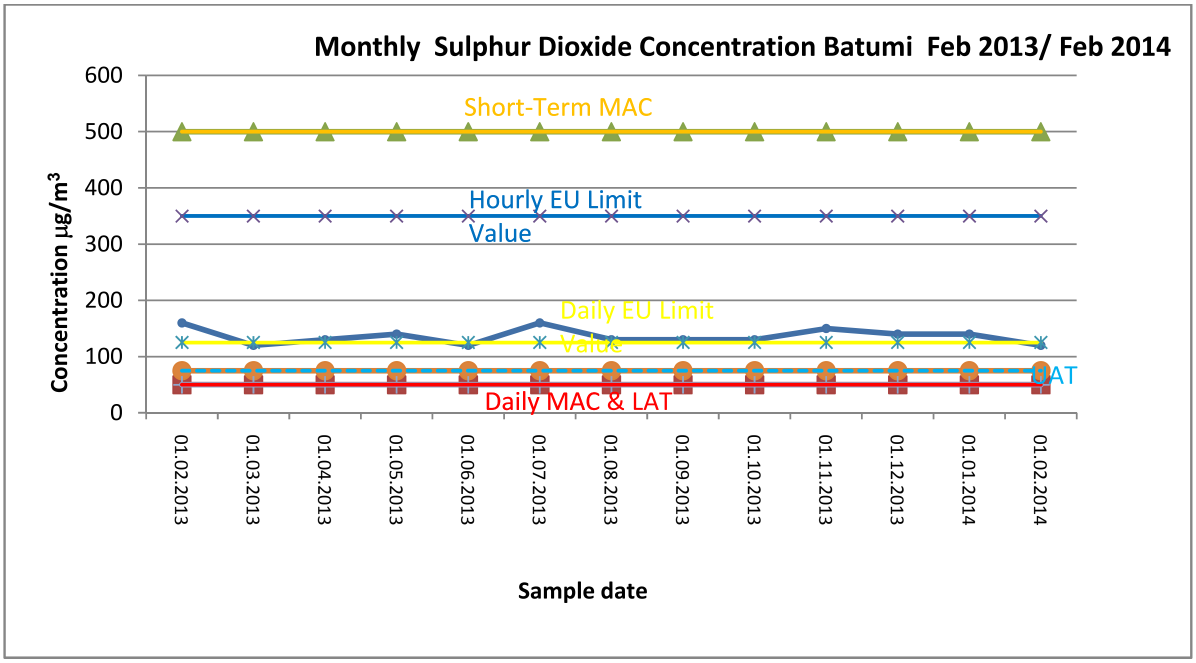


Figure 69. 2013 February-2014 February average monthly concentrations (µg/m^3) measured at Zestaponi ambient air quality monitoring site

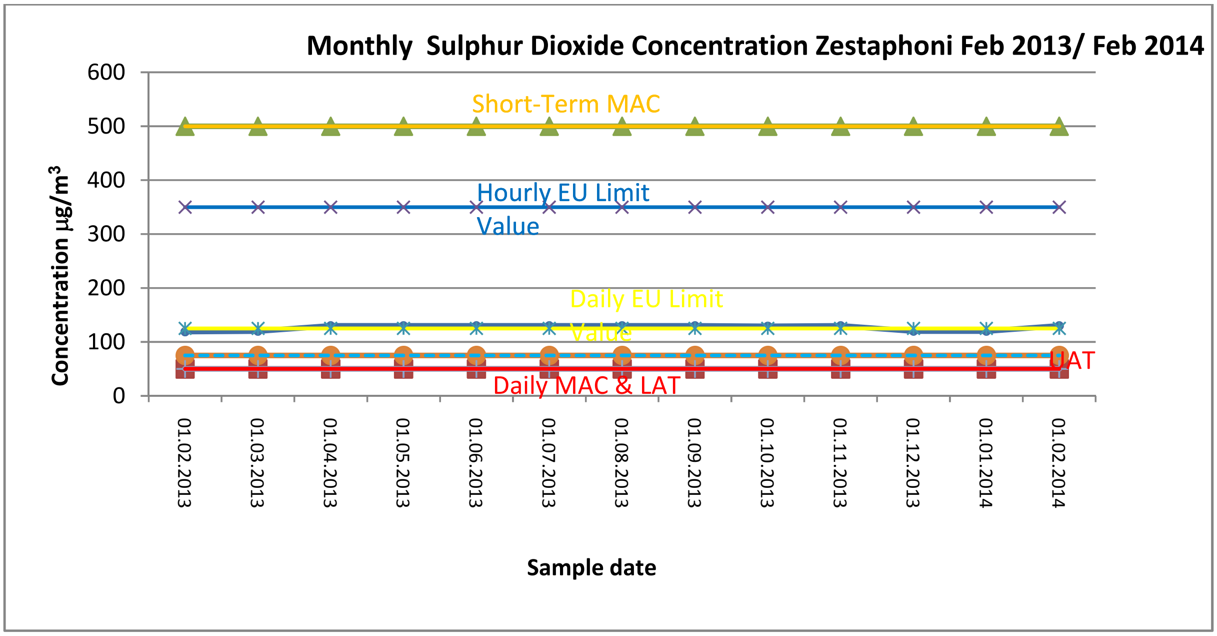


Figure 70. 2013 February-2014 February average monthly concentrations (µg/m^3) of SO_2 measured at Kutaisi ambient air quality monitoring site

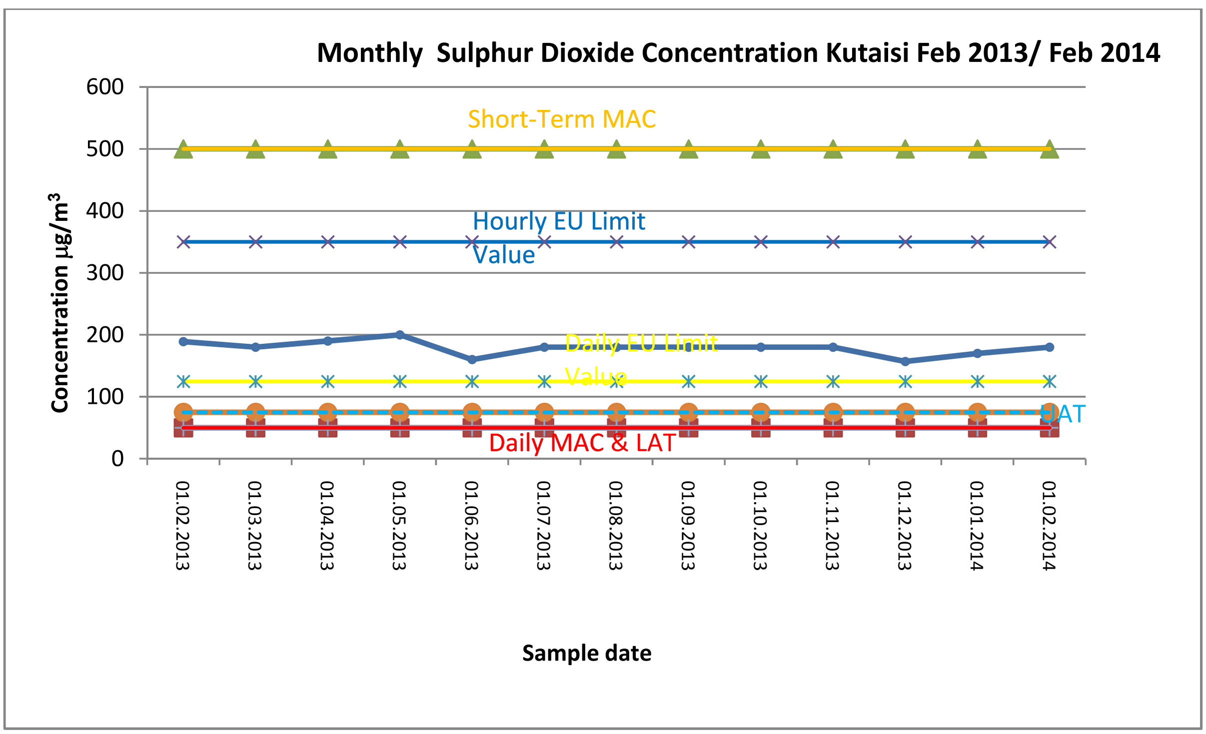
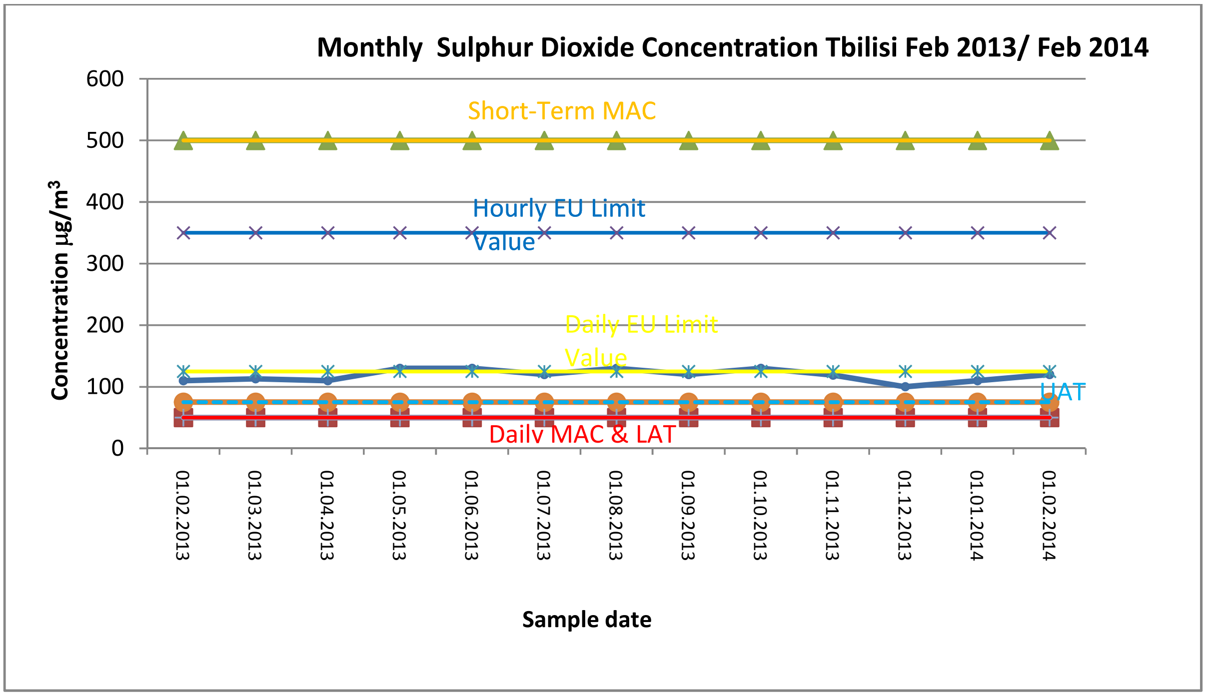


Figure 71. 2013 February-2014 February average monthly concentrations (µg/m^3) of SO_2 measured at Tbilisi ambient air quality monitoring site



All of the above city monitoring sites (Batumi, Zestaponi, Kutaisi and Tbilisi) returned monthly SO_2concentrationsin excess of 100 µg/m^3. With Kutaisi experiencing the highest monthly SO_2average concentrations approaching 200 µg/m^{3}for the months of February, April and May 2013.

At the sample locations, all of the above Georgia cities have been observed to routinely exceed SO_2 the daily MAC of SO_2 and well as the LAT, UAT and daily limit values in all four cities.

Sulphur dioxide monitoring methods used throughout Georgia, do not follow ISO reference methods and ambient air sampling is restricted to the mid-week day time periods only. This sampling arrangement excludes times within any given 24 hr period when local SO_2emissions would diminish such hours between midnight and 6am, as well as weekend periods. Excluding periods when minimum pollutant concentrations would occur artificially raises the baseline SO_2 concentration, resulting in monitoring results averages appearing much higher than they may well be.

8.3.2 Modelling Results for SO_2

Imereti

Imeritiregion has been recorded as having one of the largest emissions of SO_2across all of theregions of Georgia (see Figure 37). Dispersion modelling outputs have not reflected this magnitude of SO_2 emissions in the resulting ambient air concentrations. At this stage hourly and winter distributions of SO_2 were not derived, due to current underlying uncertainties within the emissions data.

Kutaisi: Annual average modelled concentrations of $SO_2$are lower than anticipated and neitherreflect the emissions inventory of the current record of SO_2 monitoring data. Revisions to this model will be undertaken and updated.

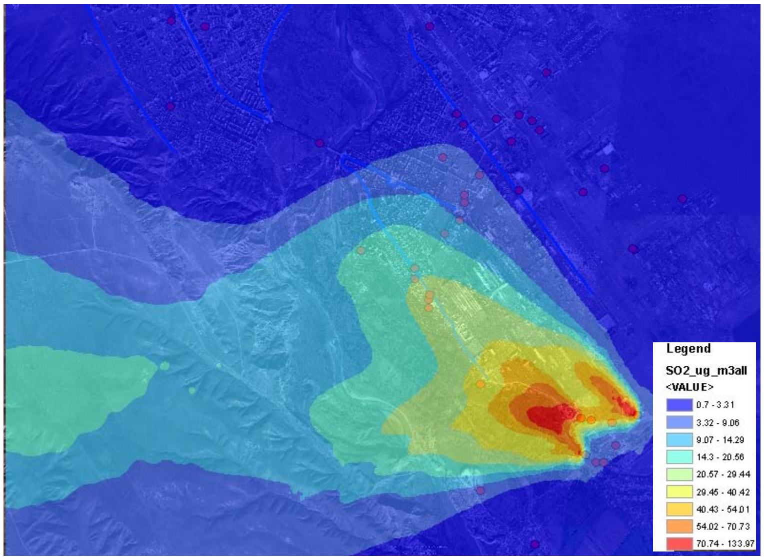
Zestaponi: Annual average modelled concentrations of SO_2 are lowers than anticipated and neither reflects the emissions inventory of the current record of SO_2 monitoring data. Revisions to this model will be undertaken and updated.

Chiatura: Annual average modelled concentrations of SO_2 are lowers than anticipated and neither reflects the emissions inventory of the current record of SO_2 monitoring data. Revisions to this model will be undertaken and updated.

Rustavi

Rustavi: Modelled concentrations of sulphur dioxide have indicated that annual mean sulphur dioxide concentrations across large areas of Rustavi will remain below 9.05$\mu g/m^3$. Sulphur dioxide concentrations across the city have been predicted to range between 0.70 to 133.97$\mu g/m^3$. Concentrations at receptor locations within 1 kilometre to the major emissions source within the Rustavi Steel Plant in Rustavi, are predicted to be in excess of 20.57$\mu g/m^3$ as an annual mean. Sulphur dioxide concentrations rise rapidly in areas very close to the Plant, with sulphur dioxide in ambient air reaching a maxima of 133.97 $\mu g/m^3$ within 200 metres of the plant stack. Elsewhere ambient concentrations of sulphur dioxide were predicted to remain close to the background, with no significant contribution from any diffuse or point sources in Rustavi.

Figure 74 Modelled Annual Mean SO_2 Concentration (μg/m3) Distribution across Rustavi, Georgia



8.4 Concentrations and Geographical Distribution of Nitrogen Dioxide in Georgia

8.4.1 Monitoring Results for NO_2

Nitrogen dioxide is continuously monitored in 5 cities within Georgia. Monitoring was not undertaken using non-reference methods (with exception of the new Tbilisi station in 2013).

Figures 75 to 79 contain monthly ambient air quality monitoring data (for 2013/2014) and annual (2008 to 2013) concentrations of monitored NO_2 for the cities of Batumi, Zestaponi, Rustavi, Kutaisi and Tbilisi.

Figure 72. 2013 February-2014 February average monthly concentrations (μg/m3) of NO_2 measured at Batumi ambient air quality monitoring site

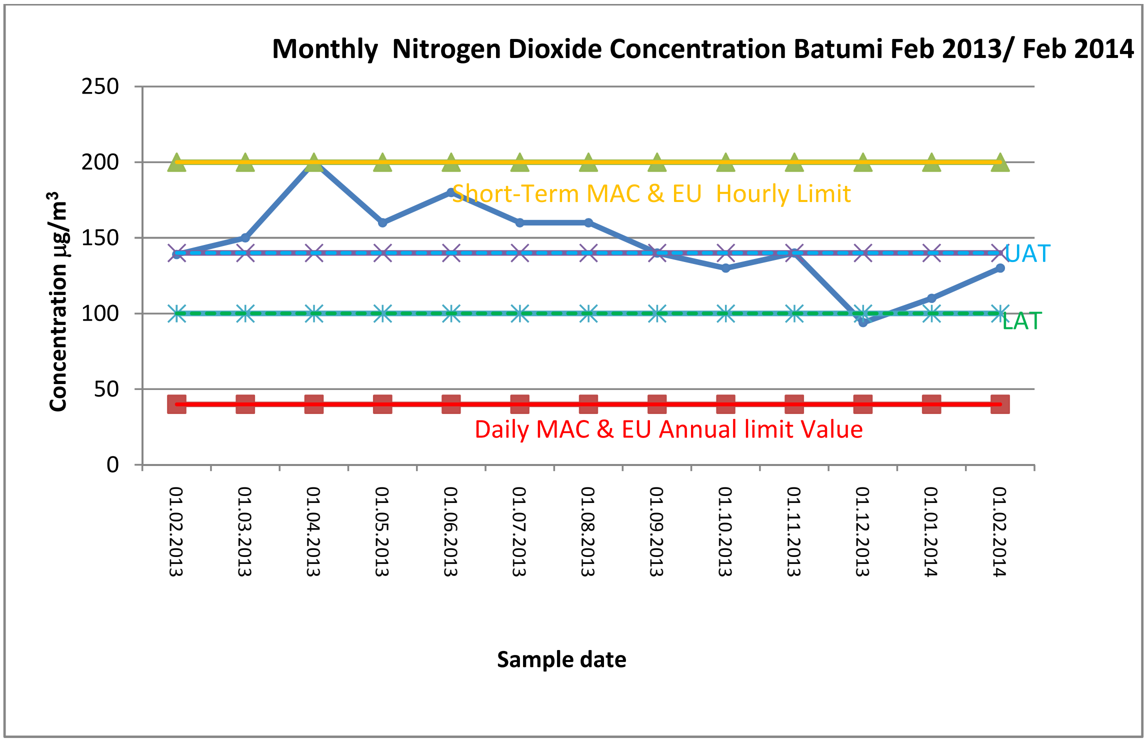


Figure 73. 2013 February-2014 February average monthly concentrations (µg/m3) of NO_2 measured at Zestaponi ambient air quality monitoring site

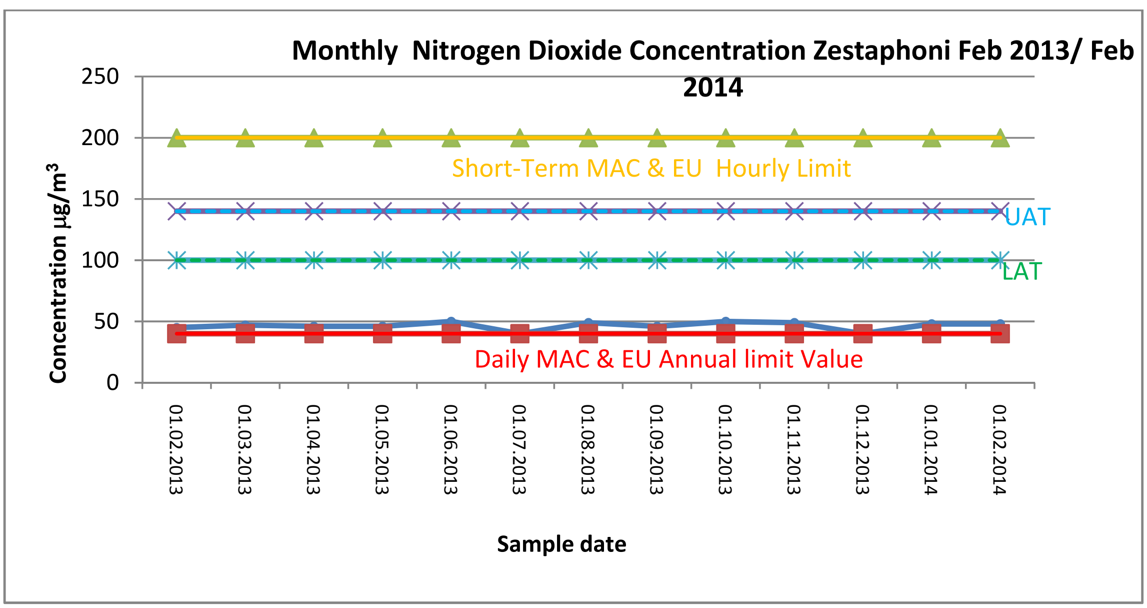


Figure 74. 2013 February-2014 February average monthly concentrations (µg/m3) of NO_2 measured at Rustavi ambient air quality monitoring site

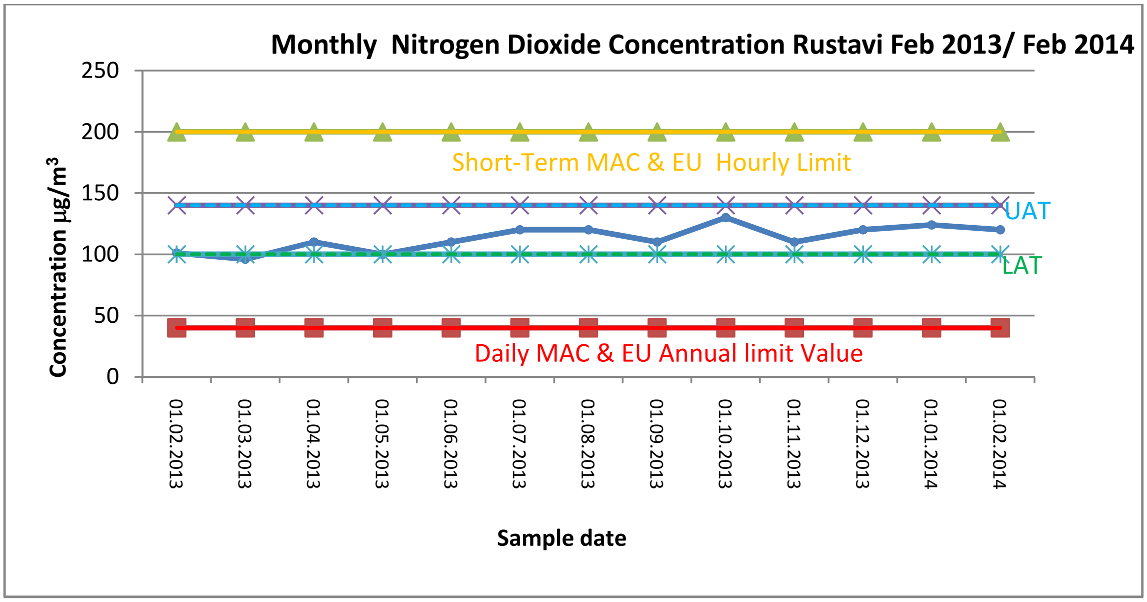


Figure 75. 2013 February-2014 February average monthly concentrations (µg/m3) of NO_2 measured at Kutaisi ambient air quality monitoring site

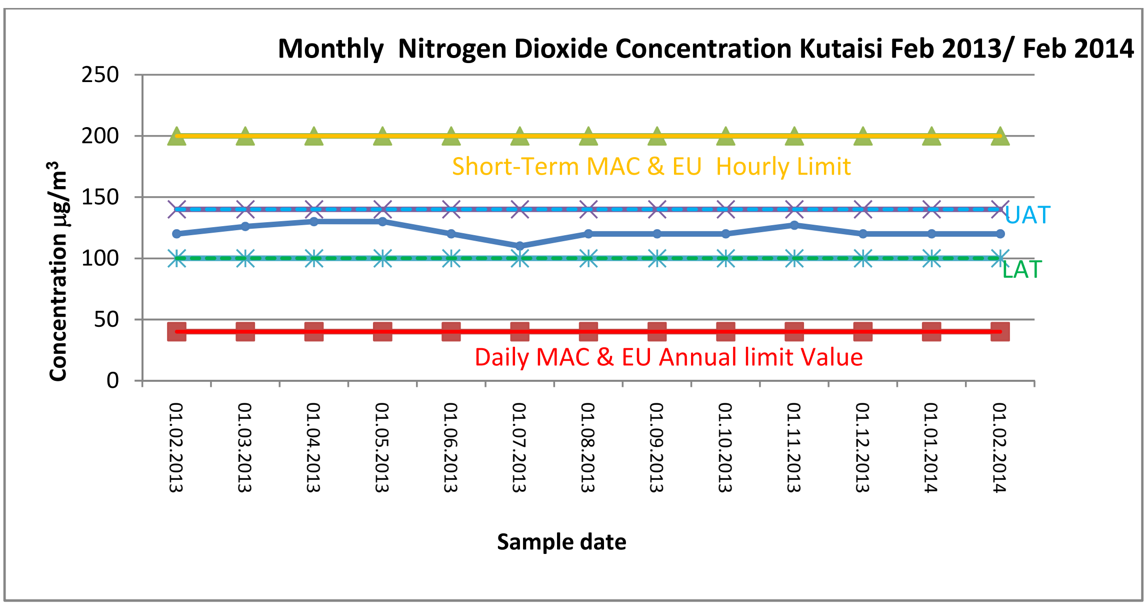
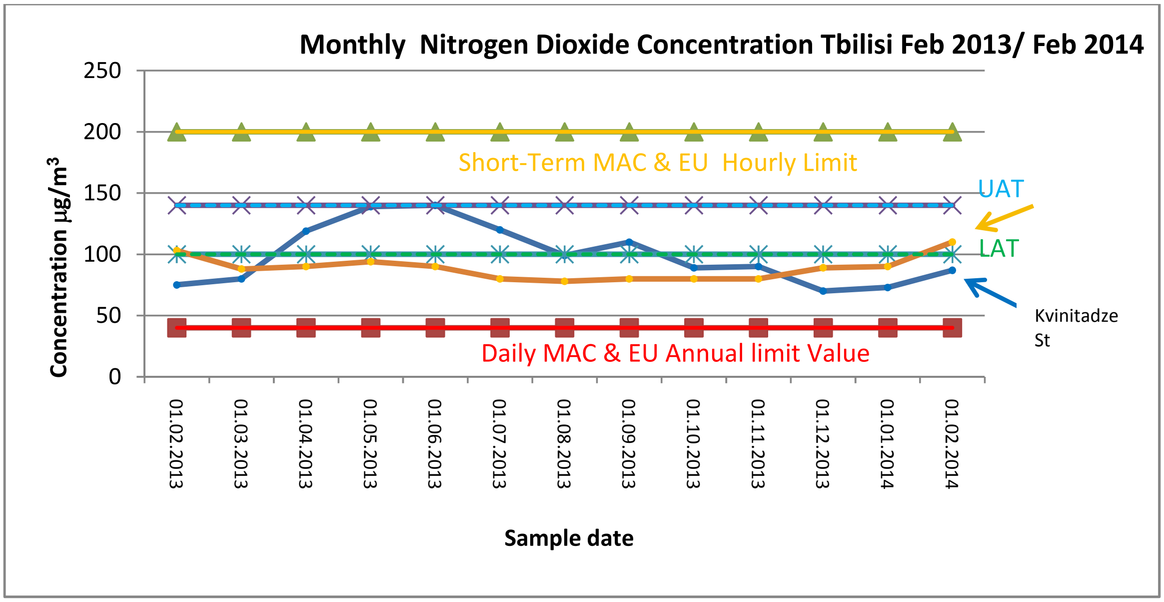


Figure 76. 2013 February-2014 February average monthly concentrations (µg/m3) of NO_2 measured at Tbilisi ambient air quality monitoring site



At all six monitoring stations average monthly nitrogen dioxide concentrations exceeded the daily MAC and EU annual limit value. LAT were exceeded at Kvinitadze St, Tbilisi, Kutaisi, Rustavi and Batumi. At Batumi both the UAT for hourly NO_2 and the short-term MAC were exceeded. Though the NO_2 concentrations at the Zestaponi monitoring station exceeded the EU annual average limit value, they remained well below the LAT for hourly NO_2 and where consistently below 50 µg/m^{3}foreach of the months reported.

A similar pattern can be observed between the monthly nitrogen dioxide concentrations at Batumi and both of the Tbilisi monitoring stations, in which NO_2 drops to a minimum during the month of November and rises towards the months of May and June. This implies that emission sources and meteorological condition are similar at each of those three sites.

Though ambient concentrations of NO_2 are high at the Zestaponi monitoring station, it is the least polluted of the six city monitoring locations. However the specific location of the air quality monitoring station at Zestaponi could have some overwhelming influence upon the lower NO_2 concentration such as its proximity to busy roads, etc.

Annual averages for NO_2at all monitoring stations, reported earlier in Table 2 of Chapter 6, confirm that NO_2concentrations consistently exceeded the EU annual limit value of 40 µg/m^{3}between 2008 and 2013. Therefore levels of NO_2in and around the monitoring station located in Batumi, Zestaponi, Chiatura, Kutaisi, Rustavi and Tbilisi are above the EU annual average limit value, and in some instances at risk of exceeding the hourly limit value of 200 µg/m^3.

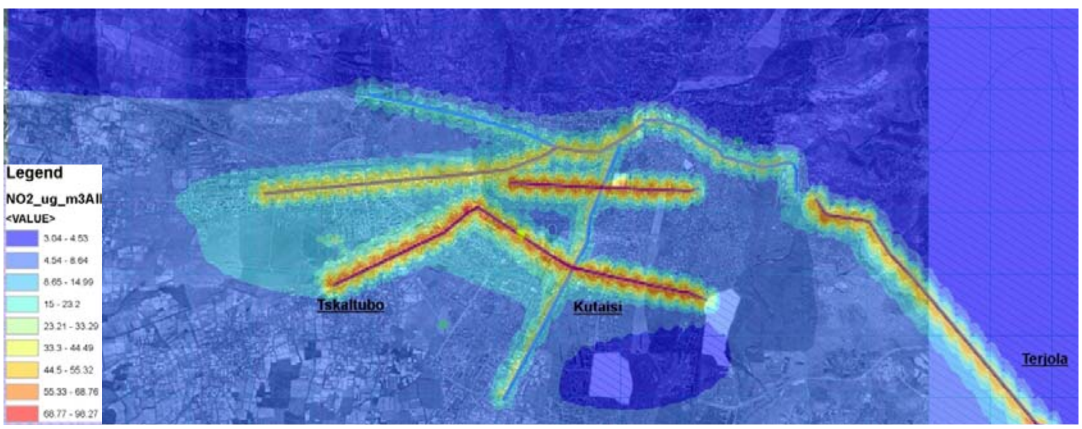
8.4.2 Modelling Results for NO_2

Imereti

The region of Imereti has been identified as emitting a significant proportion of the national inventory oxide of nitrogen (Figure 35). Concentrations of nitrogen dioxide across the region would be expected to vary across the region with potential exceedences occurring in some urban areas of the region.

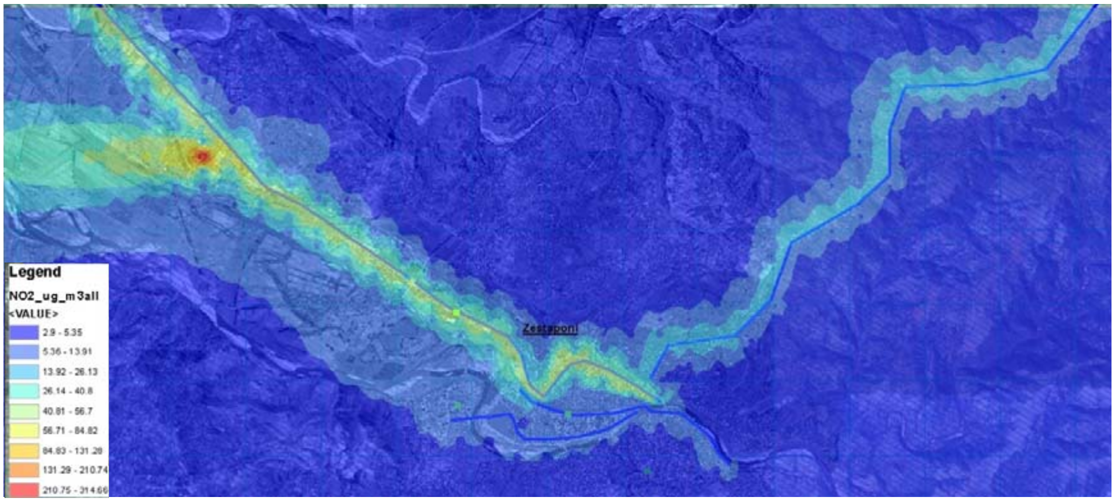
Kutaisi: Modelled concentrations of nitrogen dioxide have indicated that the annual mean ofnitrogen dioxide across large areas of Kutaisi will remain below 23.2 $\mu g/m^3$, and will vary between 3.04 to 23.2$\mu g/m^3$.At selected receptors hourly concentrations were predicted as ranging between 21.12 to 149.67 $\mu g/m^3$ (Table 16). Nitrogen dioxide annual averages were predicted to exceed EU air quality limit values along major roads throughout Kutaisi. Therefore it is predicted that nitrogen dioxide concentrations would exceed the EU annual limit value of 40 $\mu g/m^3$,though the hourly limit value has been predicted to not be at risk of being exceeded. Air quality modelling has predicted that both lower and upper assessment thresholds for annual mean and hourly mean of nitrogen dioxide are likely to be exceeded at limited receptor locations in Kutaisi (Table 14).

Figure 77. Modelled Annual Mean NO2Concentration (μg/m3)Distribution across Kutaisi, Georgia



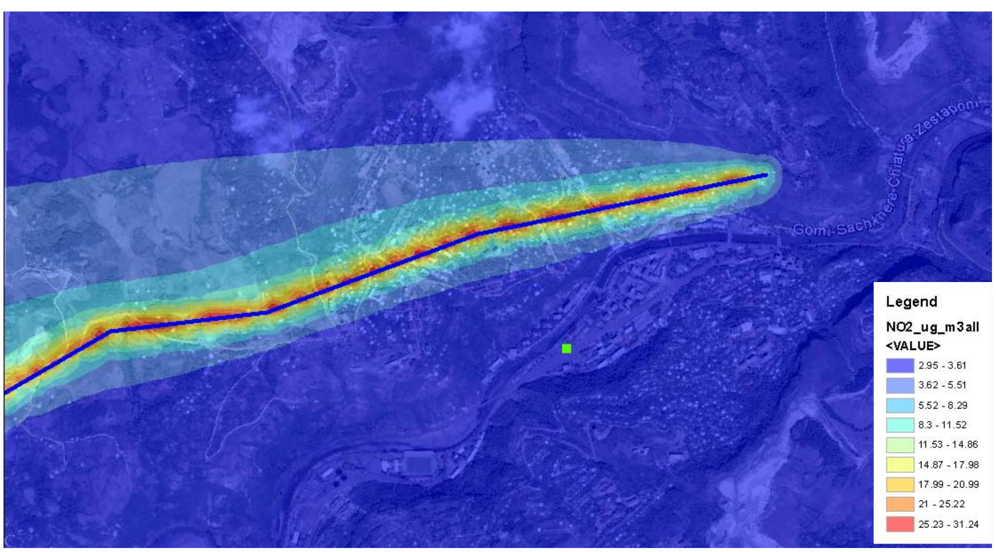
Zestaponi: Modelled concentrations of nitrogen dioxide have indicated that the annual mean of nitrogen dioxide across the area of Zestaponiwill largely vary between 2.9 to 25.1$\mu g/m^3$ and the hourly concentrations from 6.05to 105.23$\mu g/m^3$ (Table 16).Nitrogen dioxide annual averages were predicted to exceed EU air quality limit values in areas which are in close proximity to a single point source to the west of Zestaponi and alongthe two major roads passing through Zestaponi, including the E60 to the west and the Gomi-Sachkhere-Chiatura-Zestaponi road the north east of the city. Therefore nitrogen dioxide concentrations have been predicted as being at risk of exceeding the EU annual limit value of 40 $\mu g/m^3$ at a limited number of receptors locations. Hourly limit values have beenpredicted as falling well below the 200 $\mu g/m^3$EU limit value. Air quality modelling has predicted that both lower assessment thresholds for annual mean and hourly mean of nitrogen dioxide are likely to be exceeded at one receptor location in Zestaponi. And the upper assessment threshold for annual mean nitrogen dioxide alone is likely to be exceeded within at least one selected receptor location in Zestaponi (Table 14).

Figure 78. Modelled Annual Mean NO2 Concentration (µg/m3)Distribution across Zestaponi, Georgia



Chiatura: Annual mean concentrations of nitrogen dioxide modelled at Chiaturawere predicted as largely remaining below 3.61µg/m^3 and,at selected receptor locations (Table 16);an hourly maximum of 15.49 µg/m^3 has been predicted.Dispersion modelling has predicted that annual average nitrogen dioxide concentrations in Chiaturawould approach their maxima in areas immediately adjacent to major road routes. However these NO_2 maxima would not exceed 31.24 µg/m^3. Therefore neither nitrogen dioxide EU annual mean limit values nor hourly limit values were predicted as being at risk of being exceeded in Chiatura. Modelling of nitrogen dioxide concentrations at a single receptor location in Chiatura predicted that neither upper norlower assessment threshold values were at risk of being exceeded(Table 16).

Figure 79. Modelled Annual Mean NO2(µg/m3)Concentration Distribution across Chiatura, Georgia



Rustavi

Rustavi: Modelled concentrations of sulphur dioxide have indicated that annual mean nitrogen dioxide concentrations across large areas of Rustavi are likely to rise above 12.08μg/m^3. Nitrogen dioxide concentrations across the city have been predicted to range between 2.44 to 46.32μg/m^3.Nitrogen dioxide concentrations are elevated close to the Rustavi steel plant and at receptor locations close to the E60 highway and the Rustavi-Gardabani-Vakhtangisi road. Modelling has predicted that prevailing conditions will result nitrogen dioxide concentrations being elevated at receptors locations to the north east of the Rustavi steel plant.Nitrogen dioxide concentrations have been predicted to rise in areas very close to the steel plant, with nitrogen dioxide in ambient air reaching a maxima of 46.32μg/m^3 within 200 metres of the plant stack. Elsewhere in Rustavi annual mean ambient concentrations of nitrogen dioxide were predicted to remain below 21.37μg/m^3. Modelling have predicted that there is a high risk that the EU annual limit value for nitrogen dioxide (40μg/m^3) will be exceeded at a limited number of receptor locations. Conversely, modelling has predicted that there is a very low risk of the hourly limit value (200μg/m^3) being exceeded in Rustavi.

Figure 80. Modelled Annual Mean NO2 Concentration (μg/m3) Distribution across Rustavi, Georgia

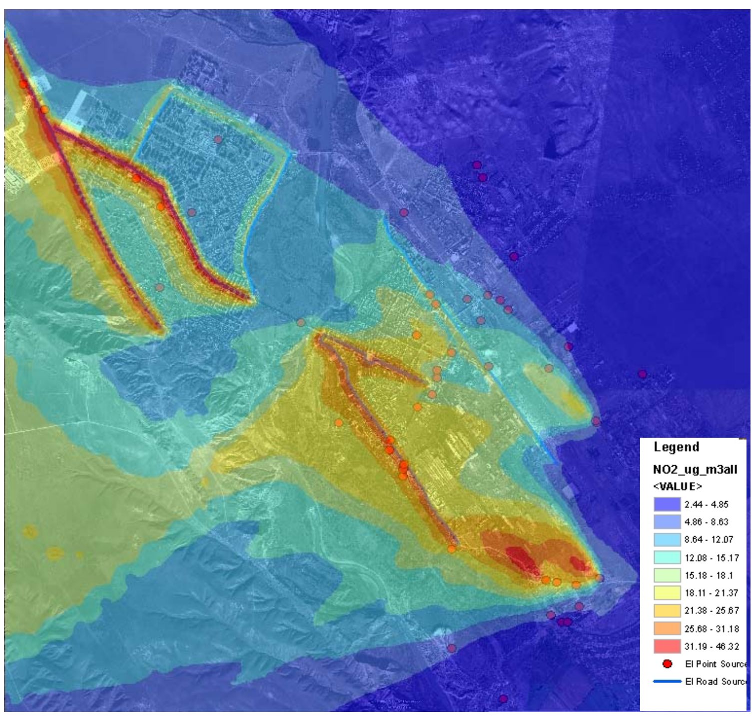


Table 14. Modelling output Concentrations of NO2(μg/m3)at selected Receptors locations in Georgia

City	Receptor	NO_2 Annual Mean μg/m^3	NO_2 Hourly Maxima μg/m^3

Kutaisi	Cemetery	4.96	21.12
	Chavchavadze	69.80	149.67
	Sapichkia	8.60	26.67
Zestapoti	"55"	3.22	6.05
	Agmashenebli	14.13	32.03
	Kvaliti	3.05	7.03
	Chikashua	4.91	16.02
	Saqkabeli	41.53	105.23
Chiatura	Chavchavadz	5.27	15.49
Rustavi	Rustavi 1	14.67	42.33
	Rustavi 2	10.11	29.57
	Rustavi 3	19.19	47.82
	Rustavi 4	2.43	2.43
	Rustavi 5	2.91	3.52
	Rustavi 6	2.92	3.55
	Rustavi 7	2.64	3.46

8.5Concentrations and Geographical Distribution of PM_{10} in Georgia

8.5.1 Monitoring Results for PM_{10}

The Georgia air quality network has only recently begun to monitor for PM_{10} within Tbilisi. At all of the national air quality monitoring stations, dust and not PM_{10} has been monitored.

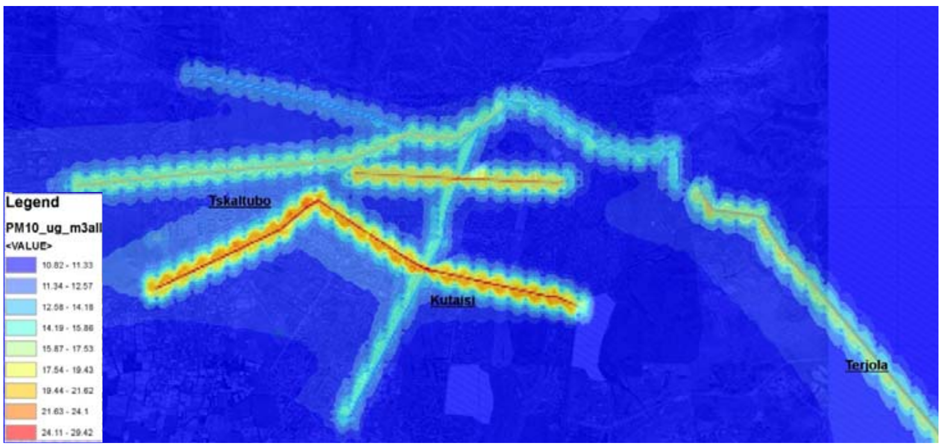
8.5.2Modelling Results for PM_{10}

Imereti

The region of Imereti has been identified as emitting a low density of total suspended particulates per square kilometre (Figure 40), though as one of the larger regions, produces a significant proportion of the national inventory of TSP (Figure 39). Concentrations of PM_{10} are expected to vary across the region, though remain relatively low.

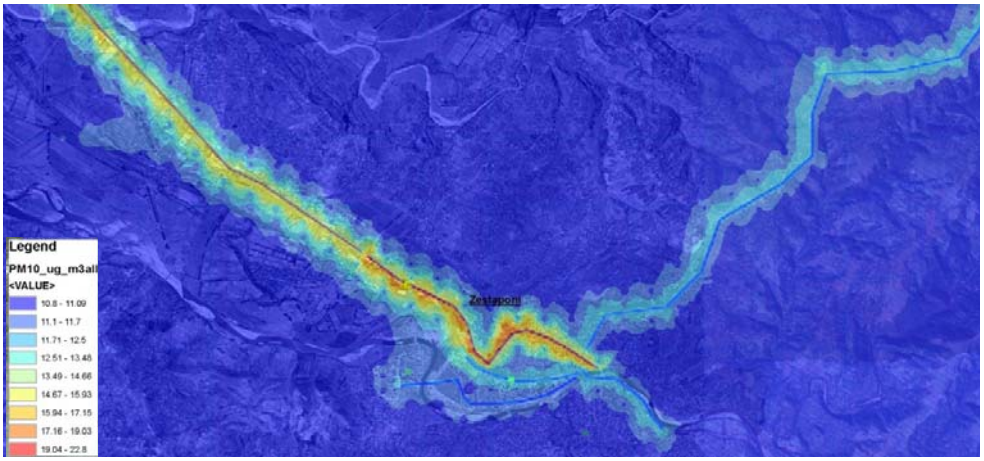
Kutaisi: Modelled concentrations of PM_{10} have indicated that the annual meanPM_{10}across large parts of Kutaisi would remain below 12.57 $\mu g/m^3$. Annual mean PM_{10} concentrations were predicted to vary between 10.82 to 29.42μg/m^3 and 24 hourly concentrations at selected receptor locations would vary between maxima of 11.10 to 26.87μg/m^3 (Table 15). Therefore it is predicted that PM_{10} concentrations would remain below the EU annual limit value of 40 μg/$m^3$and the 24 hourly limit value is also predicted as not at risk of being exceeded.Modelling of PM_{10}concentrations in Kutaisi has predicted that the lower assessment thresholds for both the annual mean and 24 hourly mean of $PM_{10}$are likely to be exceeded at one receptor location in Kutaisi. The upper assessment threshold for both the PM_{10}annual mean and 24 hourly mean are highly unlikely to be exceeded within Kutaisi.

Figure 81. Modelled Annual Mean PM10 Concentration (μg/m3)Distribution across Kutaisi, Georgia



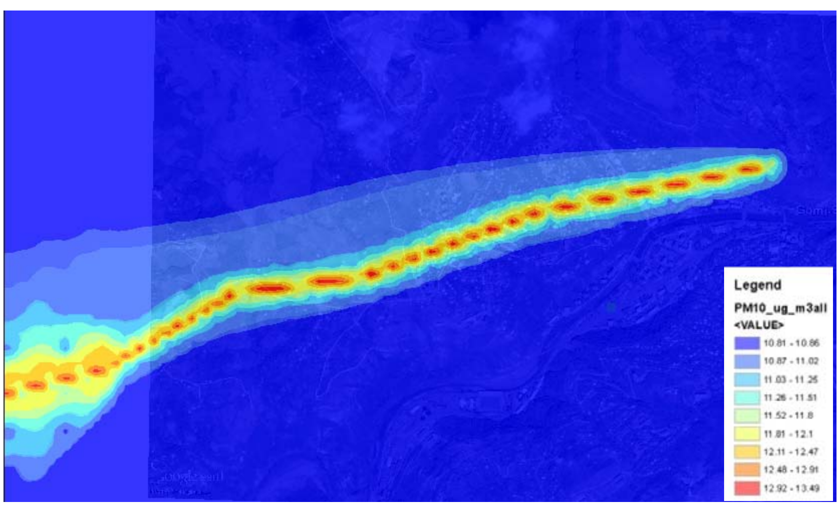
Zestaponi: Modelled concentrations of PM_{10} have indicated that the annual mean PM_{10} across the majority of Zestaponi would remain below 14.58μg/m^3. Annual mean PM_{10} concentrations were predicted to vary between 10.80 to 22.80μg/m^3 and 24 hourly concentrations at selected receptor locations would vary between maxima of 10.84 to 17.01μg/m^3 (Table 15). Therefore it is predicted that PM_{10} concentrations would remain below the EU annual limit value of 40 μg/m^3 and the 24 hourly limit value is also predicted as not at risk of being exceeded.Modelling of PM_{10} concentrations in Zestaponi has predicted that the lower assessment threshold for the 24 hourly mean of $PM_{10}$is unlikely to be exceeded. However the lower assessment threshold for PM_{10} is predicted as at risk of being exceeded. Both the upper assessment threshold for both the PM_{10} annual mean and 24 hourly mean are highly unlikely to be exceeded within Zestaponi.

Figure 82. Modelled Annual Mean PM10 Concentration (μg/m3) Distribution across Zestaponi, Georgia



Chiatura: Modelling concentrations of PM_{10}in Chiaturabeen predicted that the annual mean PM_{10} across Chiaturawould remain below 13.49μg/m^3 at all locations, Annual mean PM_{10} concentrations were predicted to vary between 10.81 to 13.49μg/m^3 and a 24 hourly maxima concentration was predicted not to exceed 11.07 μg/m^3 (Table 15). Therefore it is predicted that PM_{10} concentrations would remain below the EU annual limit value of 40 μg/m^3 and the 24 hourly limit value is also predicted as not at risk of being exceeded.In additionthe lower assessment threshold and upper assessment threshold for both the annual average and 24 hourly mean of $PM_{10}$are both recognised as unlikely to be exceeded.

Figure 83. Modelled Annual Mean PM10 Concentration (μg/m3) Distribution across Chiatura, Georgia



Rustavi

Rustavi: Modelling concentrations of PM_{10}in Rustavi been predicted that the annual mean PM_{10} across the majority of Rustavi would remain below 11.13μg/m^3. Annual mean PM_{10} concentrations were predicted to vary between 10.80 to 38.97 μg/m^3. Therefore it is predicted that there is a slight risk that PM_{10} concentrations would exceed EU annual limit value of 40 μg/m^3 and a high risk that they would exceed the 24 hourly limit valueat a limited number of locations. All potential exceedences are associated with major road routes through Rustavi and potentially attributed to vehicle emissions rather that the point source emissions of the Rustavi steel plant. receptors locations is also predicted as not at risk of being exceeded.In additionthe lower assessment threshold and upper assessment threshold for both the annual average and 24 hourly mean of $PM_{10}$are both recognised as unlikely to be exceeded. All LATs and UAT for 24 hourly mean and annual mean are at risk of being exceeded in Rustavi at a limited number of receptor locations.

Figure 84. Modelled Annual Mean PM10 Concentration (µg/m3) Distribution across Rustavi, Georgia

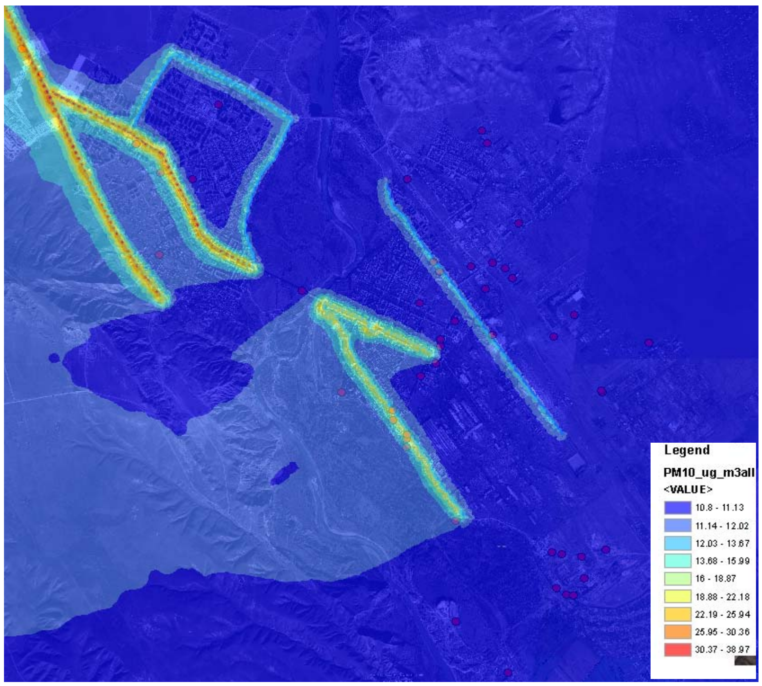


Table 15. Modelling output Concentrations of PM10 (µg/m3) at selected receptor locations in Georgia

City	Receptor	PM_{10} Annual Mean$\mu g/m^3$	PM_{10}24 Hourly Maxima$\mu g/m^3$
Kutaisi	Cemetery	10.93	11.10
	Chavchavadze	21.49	26.87
	Sapichkia	11.19	11.57
Zestapoti	“55”	10.82	10.84
	Agmashenebli	13.00	13.89
	Kvaliti	10.81	10.82

	Chikashua	10.94	11.12
	Saqkabeli	14.94	17.01
Chiatura	Chavchavadz	10.92	11.07
Rustavi	Rustavi 1	11.83	11.98
	Rustavi 2	11.04	11.11
	Rustavi 3	11.20	11.32
	Rustavi 4	10.80	10.80
	Rustavi 5	10.81	10.82
	Rustavi 6	10.81	10.81
	Rustavi 7	10.80	10.81

8.6 SUMMARY

Air Quality across Georgia has been assessed using a combination of continuous monitoring, diffusion tube monitoring and modelling techniques.

Continuous monitoring predicted that multiple exceedances of LATs, UAT and LVs would occur across a number of cities in Georgia. Passive sampling reducedthe number of predicted exceedances that would occur for nitrogen dioxide, and modelling reduced these further. A summary of each approach is contained in Table 16 below, with indications where LATs, UATs or LVs have been estimated of being reached or exceeded.

Table 16. Varying Predictions of CAFE Directive LV's, LAT and UAT Exceedances across Georgia applying the three Assessment Methods

Assessment Method	SO_2	NO_2	PM_{10}	CO	O_3
Batumi					
Continuous Monitoring	Daily LAT, Daily UAT, Daily LV, Annual LAT, Annual UAT, Annual LV	Hourly LAT, Hourly UAT, Hourly LV, Annual LAT, Annual UAT, Annual LV	Daily LAT, Daily UAT, Daily LV, Annual LAT, Annual UAT, Annual LV	No exceedances	N/A
Modelling				N/A	N/A
Passive Sampling		Hourly LAT, Hourly LV, Annual LAT, Annual UAT, Annual LV	N/A	N/A	N/A
Zestapoti					
Continuous Monitoring	Daily LAT, Daily UAT, Daily LV, Annual LAT,	Annual LAT, Annual UAT,	Daily LAT, Daily UAT, Daily LV, Annual LAT,	No exceedances	N/A

	Annual UAT, Annual LV	Annual LV	Annual UAT, Annual LV		
Modelling		Hourly LAT, Annual LAT, Annual UAT, Annual LV	No exceedances	N/A	N/A
Passive Sampling		Annual LAT, Annual UAT,	N/A	N/A	N/A
Chiatura					
Modelling	No exceedences	No exceedances		N/A	N/A
Passive Sampling				N/A	N/A
Kutaisi					
Continuous Monitoring	Daily LAT, Daily UAT, Daily LV, Annual LAT, Annual UAT, Annual LV	Hourly LAT Hourly UAT, Hourly LV, Annual LAT, Annual UAT, Annual LV	Daily LAT, Daily UAT, Daily LV, Annual LAT, Annual UAT, Annual LV		N/A
Modelling		Hourly LAT Hourly UAT, Annual LAT, Annual UAT, Annual LV		N/A	N/A
Passive Sampling		Annual LAT, Annual UAT,	N/A	N/A	N/A
Rustavi					
Continuous Monitoring	N/A	Hourly LAT Hourly UAT, Hourly LV, Annual LAT, Annual UAT, Annual LV		No exceedances	N/A
Modelling	Daily LAT Daily UAT Daily LV	Annual LAT Annual UAT Annual LV	Daily LAT, Daily UAT, Daily LV, Annual LAT, Annual UAT	N/A	N/A
Passive Sampling		No exceedences	N/A	N/A	N/A
Tbilisi					
Continuous Monitoring	Daily LAT, Daily UAT, Daily LV, Annual LAT, Annual UAT, Annual LV	Hourly LAT Hourly UAT, Hourly LV, Annual LAT, Annual UAT, Annual LV	Daily LAT, Daily UAT, Daily LV, Annual LAT, Annual UAT, Annual LV	No exceedances	
Modelling				N/A	N/A
Passive Sampling		Hourly LAT, Hourly LV, Annual LAT, Annual UAT, Annual LV	N/A	N/A	N/A

The combined assessment of air qualityacross the Georgian regions of Batumi, Zestaponi, Kutaisi, Chiatura, Tbilisi using monitoring data, modelling outputs and passive sampling together has providedan overview of the range of pollutant concentrations in Georgia.

Limitations associated with the current monitoring data exist,these includea lack of geographical representation (very small number of sample sites) and the lack of sampling during periods of low ambient air concentration. Combined,these limitations appear to have resulted in higher concentration averagesbeing slightly over represented. It is feasible that ambient air concentrations for both SO_2 and NO_2 may well be lower than has been reported by the monitoring data to date. Therefore when assessing the risk of either an LAT, UAT or LV being exceeded, slightly lower emphasis has been placed upon the monitoring data and a greater emphasis placed upon both modelling data and passive sampling results.

Requirement for Monitoring within Regions of Georgia

Where an UAT for a particular species has been predicted at risk of being exceeded within a region of Georgiaas a consequence of this assessment, then the CAFÉ directive requires that continuous monitoring must be put in place to determine whether that particular species may exceed its LV. Table 17 summarises which species have been identified as requiring continuous monitoring, in which region. Where the CAFÉ directive monitoring requirement has been identified as a consequenceof continuous monitoring data alone, then this is considered a conservative assessment. Where either modelling data or passive sampling has identified the need for CAFÉ directive monitoring then this may be considered to represent the minimal position.

Table 17. Regions in Georgia where Ambient Air Species Monitoring is requiredunder the CAFE Directive

Assessment Method	SO_2	NO_2	PM_{10}
Batumi			
Continuous Monitoring	Daily LV, Annual LV	Hourly LV,Annual LV	Daily LV, Annual LV
Passive Sampling		Hourly LV, Annual LV	
Zestapoti			
Continuous Monitoring	Daily LV, Annual LV	Annual LV	Daily LV, Annual LV
Modelling		Annual LV	
Passive Sampling		Annual LAT, Annual UAT,	
Kutaisi			
Continuous Monitoring	Daily LV, Annual LV	Hourly LV, Annual LV	Daily LV, Annual LV
Modelling		Hourly UAT, Annual LV	
Passive Sampling		Annual LAT, Annual UAT,	
Rustavi			

Continuous Monitoring		Hourly LV, Annual LV	
Modelling	Daily LV	Annual LV	Daily LV, Annual UAT
Tbilisi			
Continuous Monitoring	Daily LV, Annual LV	Hourly LV,Annual LV	Daily LV, Annual LV
Passive Sampling		Hourly LV, Annual LV	

The principal difference between the two positions of conservative assessment and the minimal assessment for the CAFE directive monitoring requirements, above is that the conservative position predicts that both SO_2 and PM_{10} monitoring would be required in Batumi, Zestaponi, Kutaisi, Tbilisi, whereas the minimal position predicts that only NO_2 monitoring would be required within those regions.

9. IDENTIFICATION OF ZONES AND AGGLOMERATIONS

9.1 Designation of zones and Agglomerations

EU Member States use designated zones and agglomerations to assess and manage air quality. How a zone is identified and designated depends largely on the chosen variable: size, population, measured individual pollutant or types of protection targets. EU Member States are able to define their own zone structure and characteristics (population and area). Zones can be different for different pollutants, allowing Member States the opportunity to optimize air quality management resources, as there may be differentsources or abatement strategies.

Final assignment of the zones and agglomerations shall be made after ministerial consultation and it is anticipated that as a consequence the following proposed boundaries may well be amended and realigned.

9.2 Methodology

In determining the identification and number of zones and agglomerations within Georgia the following information has been taken into account:

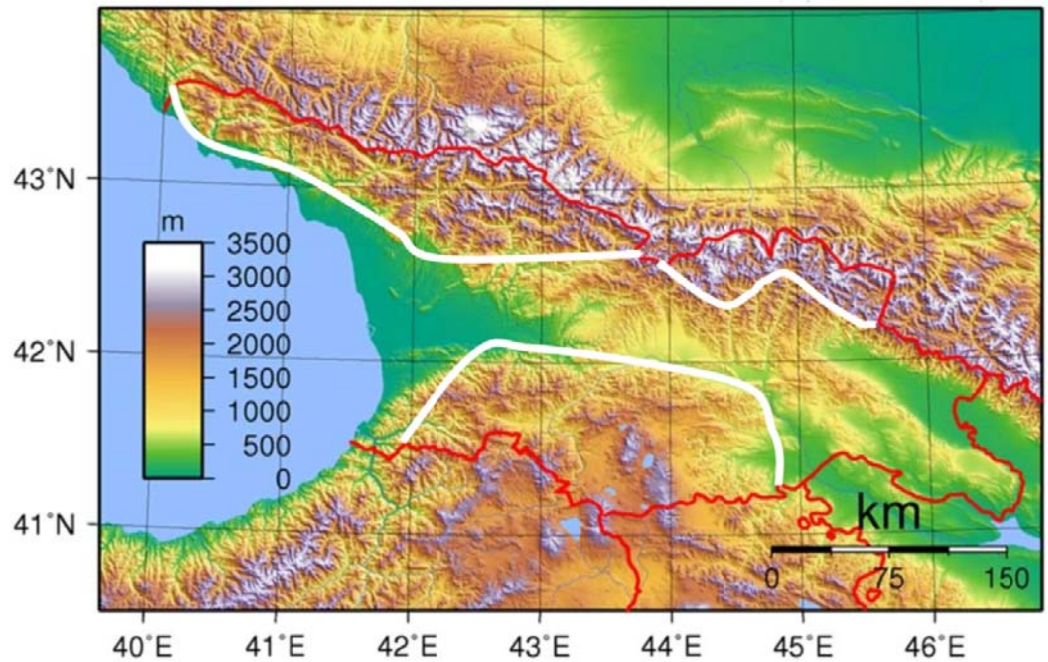
- Topography
- Climate
- Distribution of Point Source Emissions
- Population Distribution

9.3 Topography

The overwhelming variation of topography across Georgia naturally provides division between elevated areas of land and those at lower levels.

The country contains three distinct mountainous areas which have been highlighted below in figure 90 below:

Figure 85. Topography and elevation across Georgia



These are distinct from other lower lying areas of the country and can be seen to influence both climate, land use as well as population density. These three elevated areas contain characteristic which are therefore different from other area of the country and will be taken into account when distinguishing zones identities.

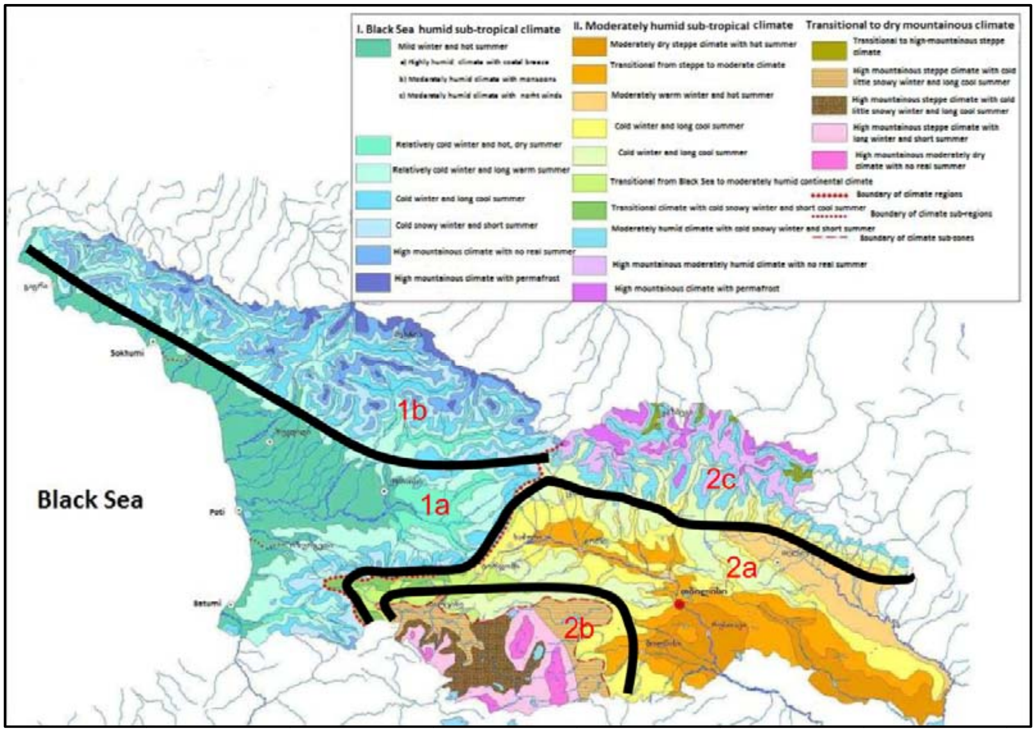
9.4 CLIMATE

As discussed at length in chapter 7, Georgia has a complex climate, largely defined by its varying elevation and proximity to the Black Sea. The land area of Georgia can be divided into the following dominating micro-climates:

1. Black Sea humid sub-tropic climate banding, with sub-divisions of
    a. mild cot winters/ hot warm summers and cold winter,
    b. high mountains/ cool, short summer and or perma-frost;
2. Moderately humid sub-tropical climate with sub-divisions of
    a. Moderately dry hot summer/ warm winter to long cool summer/ cold winter
    b. Moderately humid climate with cold snowy winter and short summer to high mountainous climate with permafrost
    c. Moderately humid climate with cold snowy winter and short summer to High mountainous moderately dry climate with nor real summer

Each of the micro-climatic areas have been illustrated in figure 102 below. It can be seen that there are 5 micro-climatic areas within Georgia.

Figure 86. Areas of distinct climatic variations across Georgia



Each microclimate will have underlying influences on the requirement for certain emission type, e.g. heating, dispersion and pollution resident periods (e.g. drier conditions will allow ambient dust levels to remain high). These climatic variations will be taken into account when distinguishing zones identities.

9.5 Distribution of Point Source Emissions

National inventory records of major point source emissions in Georgia imply that there are six concentrated areas of point source emissions in the country. These have identified and highlighted in red ellipses in figure 103 below.
These concentrated point sources are focused around the areas of:

A - Tbilisi / Rustavi;

B - the combined areas surrounding Samtredia, Kutaisi and Zestaponi;

C - Akhmeta and the Alazani Valley[30];

D - Khashuri and Gori;

E - the combined areas of Vale and Akhaltsikhe and Atskuri; and

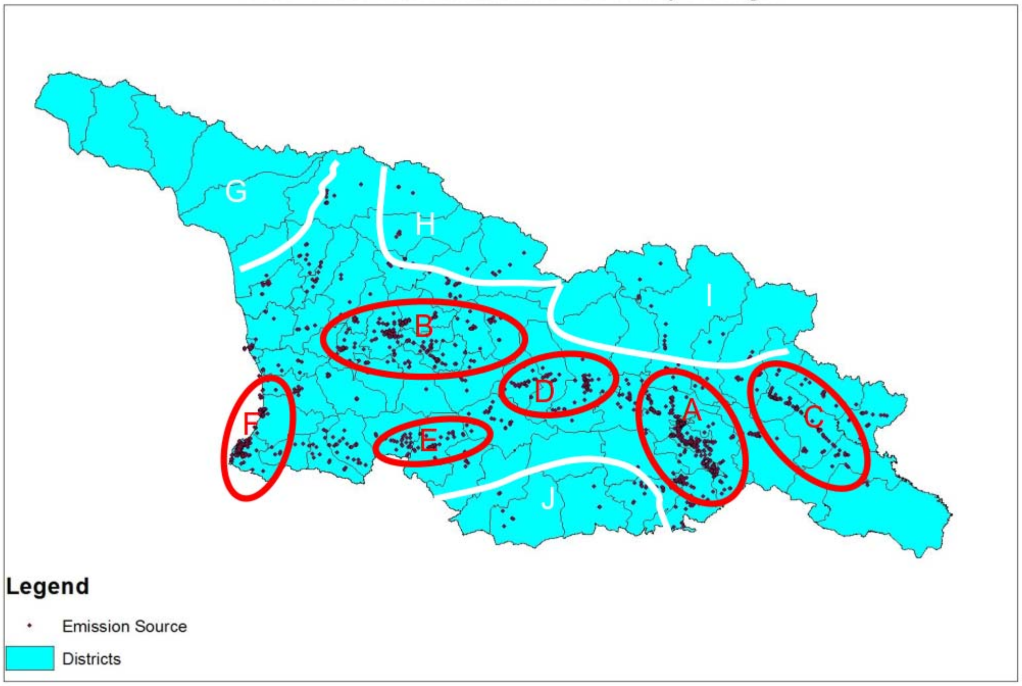
F - the combined areas of Batumi and Kobuleti.

There are four distinct areas of the country which have a very low density of point source emissions, area marked G, H, I and J below (Figure 90). Due to the low density of point source emissions within area G, H, I and J, these four areas are likely to have air quality which falls below the UAT's and therefore will attract a lower assessment regime that other

[30] Including Telavi and Gurjaani

areas of the country. It is therefore legitimate to consider whether these areas could be retained as distinct zones separate from the remaining areas of the country.

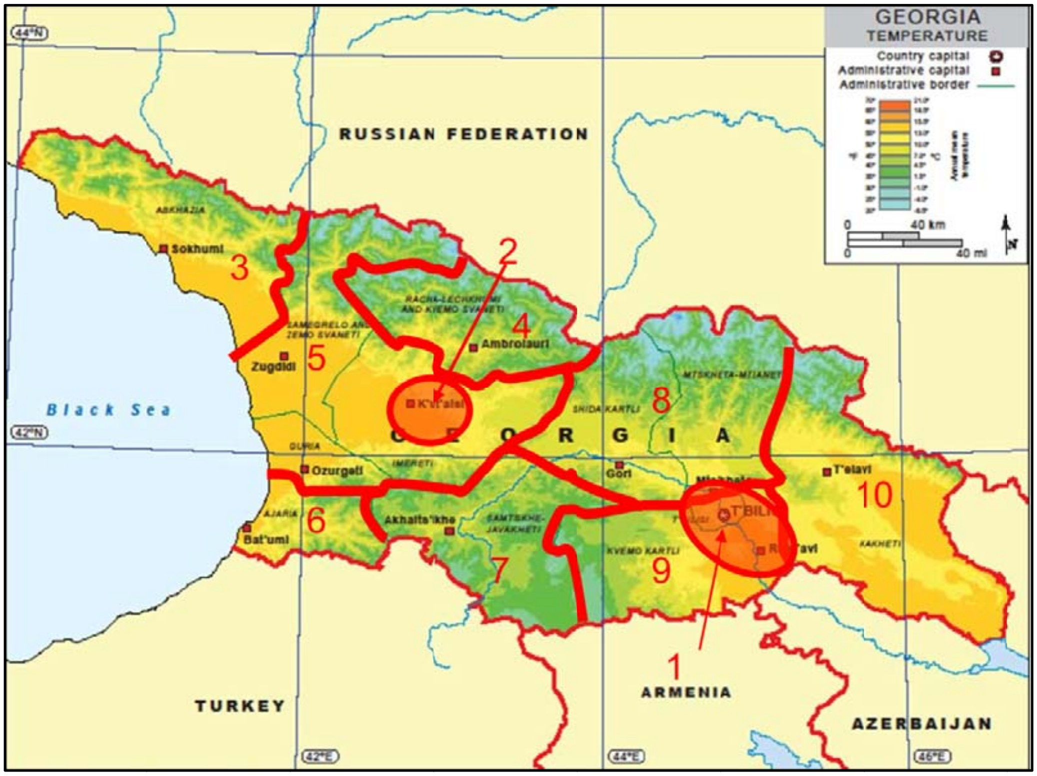
Figure 87. High density areas of point source emissions



9.6 PROPOSED ZONES AND AGGLOMERATIONS

Eight zones and two agglomerations are proposed for Georgia. These are based upon the topography, varying micro-climate and geographical distribution of point sources, which is an indication of the country's population density distribution. It should be noted here that upcoming consultation with the beneficiary and stakeholders may alter the final zones and agglomerations.

Figure 88. Proposed zones and agglomerations in Georgia



9.7 General Zones and Agglomerations in Georgia

The identification and type of zones and agglomerations in Georgia are contained in figure 104 and table 15 below. The geographical lineation for each zone has not been specified at this stage, as this will require negotiation between stakeholders and each of the individual regional administrations. This process of negotiations with the beneficiary and stakeholders may result in the redefining of the zones and agglomerations. A final list of zones and agglomerations will be provided in the Summary Report of Activity 4.

Table 15. Proposed Zones and Agglomerations in Georgia

Number	Area Description	Type
1	Tbilisi and surrounding Area	Agglomeration
2	Combined areas surrounding Samtredia, Kutaisi and Zestaponi;	Agglomeration
3	Abkhazia	Zone
4	Racha-Lechkhumi and Kvemo Svaneti	Zone
5	Samegrelo and Zemo Svaneti	Zone
6	Batumi	Zone
7	Akhaltsikhe	Zone
8	Shidakartli&Mtskheta-Mtianeti	Zone

9	KvemoKartli	Zone
10	Kakheti	Zone

9.8 SUMMARY

Ten zones have been identified for the purpose air quality monitoring and management in Georgia. Each zone reflects the varying characteristics of the state and its air quality. Where possible, the zones should be segregated so as to harmonise with existing boundaries between the various regional or autonomous area administrations. This would provide clarity to the local governing bodies of the state of the regional air quality at the National Air Quality Action Planning Stage.

10. REPORTING OF ASSESSMENT RESULTS OF AIR QUALITY IN THE ZONES AND AGGLOMERATIONS IN GEORGIA

10.1 Introduction

Air quality assessment results within zones and agglomerations are reported within a comprehensive summary of the work undertaken to demonstrate compliance with the air quality assessment requirements of the 4th Daughter and CAFEdirectives. The structure of these summary reports is outlined here.

10.2 Executive Summary

The report should outline all methods, limitations, exception and finding within a brief executive summary, in a form which a non expert would be able to digest the reports essential information. This should also contain a direct reference to the competent authorities and bodies responsible for implementation of the Directives, assessment of ambient air quality, approval of measuring devices (methods, equipment, networks, and laboratories), accuracy of measurement by measuring devices, and analysis of assessment methods.

10.3 General Approach

This section should include following components:

- Definition and identification of the existing zones and agglomerations in Georgia
- Ambient air quality concentration data inputs
- Sampling Criteria
- Minimum number of fixed monitoring sites

A list of assumptions and definitions should also be included within the General Approach, typically for the purposes of such an assessment these would contain the following:

Assumptions and Definitions for Assessment Reporting

Georgia is composed of 2 agglomerations zones and 8 non-agglomeration zones.

For pollutants except ozone (for which there is no limit values or assessment thresholds), the exceedance status each zone has been determined using measured and modelled data available over a five year period 2008-2013 and based on guidance provided by Annex II, Section B of the CAFE Directive.

Measurement methods have not followed reference methods and do not include hourly or daily data summaries. Only monthly summaries of monitoring data were available.

Measurement data is generally available for the years 2008 to 2013. The supplementary assessment data is available for most pollutants for the years 2013.

Formal exceedance was deemed to have occurred, for each zone or agglomeration, if there was exceedance of the assessment threshold on three or more years during the five year period, 2008-2013.

In determining an exceedance of the assessment threshold, precedence has been given to measurement data where this is available, unless higher concentrations are predicted elsewhere in a given zone by model outputs;

According to Article 7, Section 3 of the CAFE Directive, and the sampling criteria presented in Annex V, Table 1 of the CAFE Directive, the number of monitoring stations maybe reduced by up to 50 % where information other than fixed measurements is available. The preliminary assessment method for PM10 and PM2.5 differs from that for other pollutants since there is limited pre-existing historical datasets to calculate assessment thresholds. In this case, the network size is based on the minimum number of sampling sites to assess compliance with the exposure reduction target (see Annex V, Section B of the CAFE Directive).

No monitoring is required in cases where the ambient concentration is less than the lower assessment threshold.

For NO2 and PM10 the assessment is based on the annual average threshold.

For sulphur dioxide, the assessment is based on the 24-hour assessment threshold

For ozone, the minimum number of sampling sites is provided in Article 10 and Annex IX of the CAFE Directive.

The report should state what zones and agglomerations were used to assess the monitoring requirement under the 4th DD and CAFEDirective. These should be listed in tabular form (Table 16) and illustrated upon a map.

Table 16. Zones for Air Quality Reporting

Zone[31]	Zone Code	Agglomeration or non Agg	Population	Area (km^2)
Tbilisi and surrounding Area	1	Agg		
Combined areas surrounding Samtredia, Kutaisi and Zestaponi;	2	Agg		
Abkhazia	3	Non-Agg		
Racha-Lechkhumi and Kvemo Svaneti	4	Non-Agg		
Samegrelo and Zvemo Svaneti	5	Non-Agg		
Batumi	6	Non-Agg		
Akhaltsikhe	7	Non-Agg		
Shidakartli&Mtskheta-Mtianeti	8	Non-Agg		
KvemoKartli	9	Non-Agg		
Kakheti	10	Non-Agg		

10.4 Ambient air quality concentration data -Measurement data

Monitoring of pollutant concentrations to meet the requirements of the Framework and Daughter Directives began in 2013 at the Tbilisi air quality monitoring station.Monitoring and detection techniquesare compliant with approved reference methods and data quality objectives outlined in Annex IV of the CAFÉ Directive.The table below summarises the number of sampling sites for the year 2013 within the Georgia national monitoring network.

Table 17.Number of Sampling Sites in the National Network with a data capture greater than 75%

Number of Sampling Sites in the National Network with a data capture greater than 75%						
Year	NO2	SO2	PM10	PM2.5	Benzene	CO
2013	1	1	1	0	0	1

[31] Zones and agglomerations may be revised after consultations with the beneficiary and stakeholders.

10.5 Ambient air quality concentration data - Modelled data

A summary of the annual air quality assessments should be provided, and the years in which this has continued. Where modelled concentrations for SO_2, NO_x, NO_2, PM_{10}, $PM_{2.5}$, and CO are used to supplement the measurement data, these concentrations should be reported in the preliminary assessment. Where these are below the lower assessment, then there will be no need for further modelling (although limited measurement and emission inventory data compilation should still continue).

A table should be provided which summarises the available modelling data results of the annual air assessments carried out for the Framework and Daughter Directives.

Table18.Summary of modelling data available for the preliminary assessment of the CAFEDirective

Pollutant	Year Modelled	Used in Annual Assessment	Modelling Report Reference
SO_2			
NO_2			
NO_x			
PM_{10}			
$PM_{2.5}$			
Lead			
Benzene			
CO			
Ozone			

The following information should be reported (where available) for SO_2, NO_2:

- Supplementary assessment data
- Number of monitoring sites required for protection of human health
- Number of monitoring sites required for protection of vegetation and natural ecosystems

The following information should be reported (where available) for PM_{10} and $PM_{2.5}$:

- Supplementary data for PM_{10} and $PM_{2.5}$
- Number of sites required for compliance monitoring of particulate matter
- Observations and proposals for national exposure reduction target

The following information should be reported (where available) for Carbon Monoxide, Benzene, Lead

- Supplementary assessment data
- Model description
- Number of sites required for protection of human health

The following information should be reported (where available) for Ozone:

- Number of sites required for protection of human health Ozone
- Supplementary assessment data
- Number of sites required for protection of human health and vegetation

Other compliance requirements

- Chemical speciation of $PM_{2.5}$
- Ozone precursor substances

10.6 Reporting on 4th DD pollutants

In order to comply with 4th DD requirements, detailed metals data is required to be reported. This is to include the number of zones where 4th DD metals are monitored and the number of individual monitoring stations deployed in Georgia where 4th DD metals are sampled.

Table 19. Number of proposed stations for 4th DD Pollutants in Georgia

Number of Zones where monitored				Number of Monitoring Stations			
As	Cd	Ni	BaP	As	Cd	Ni	BaP

A summary report of the 4th DD metals exceedance status of all zones in Georgia is required, this should include specific reference to the 4th DD target

A summary report of the exceedance status of zones within Georgia with respect to the target values for arsenic, cadmium, nickel and benzo(a)pyrene should be provided in the assessment reports.

An example table is illustrated below.

Table 20. Summary report of the exceedance status of 4th DD species in Georgia zones

	As			Cd			Ni			BaP		
Zone Number	undefined	<Target Value	>Target Value	undefined	<Target Value	>Target Value	undefined	<Target Value	>Target Value	undefined	<Target Value	>Target Value
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

11. SUMMARY AND CONCLUSIONS

A preliminary assessment of air quality across Georgia has been conducted for the pollutants regulated by the CAFEDirective and Fourth Daughter's Directive on ambient air quality.

The objective of the preliminary assessment is to establish estimates for the overall distribution and levels of pollutants, and to identify air quality monitoring activities necessary to fulfil obligations to the Directive.

Measurements of air pollutants, derived from monitoring surveys and national emissions inventory data have been utilised in this preliminary assessment. These data were derived from national monitoring data gathered by the NEA as well as a passive sampling measurement campaigns commissioned by CENN as part of the Feasibility Study.

The data used in this assessment are as follows:

- National Network monitoring measurement data 2002 to 2013
- Short-term diffusive sampler measurement data for NO_2, O_3 and benzene, Tbilisi 2014.
- National Emission Inventory Data for Georgia 2013
- Dispersion modelling of point sources, area sources and mobile sources of air pollutants.

Based upon these measurements/surrogate information and guidance, it has been established that levels of air pollution in parts of Georgia are above or, where measurements are not available, likely to be above thresholds which require fixed measurements to be made for compliance with the CAFE Directive. These observations apply both for the two agglomerations zones identified in Georgia (Tbilisi and Kutaisi) and for a number of areas outside of these agglomerations. Specific monitoring requirements will be finalised in the Activity 4 report, once the Georgia Government defines the boundaries of the zones and agglomerations.

On the basis of the agglomerations and zones here defined, however, the following fixed monitoring activities are recommended for minimum compliance with both the CAFE and Fourth Daughter Directives:

Table 21. Fixed monitoring requirements for minimum compliance with the CAFE Directive within Georgia

Proposed Zone/agglomeration Number	Proposed Zone/agglomeration	Pollutants to be monitored	Category of Sampling Location required
1	Tbilisi	NO_x, SO_2, PM_{10}, $PM_{2.5}$,	Roadside location in Tbilisi
		NO_x, SO_2, PM_{10}, $PM_{2.5}$	Urban Background location in Tbilisi
		NO_x, SO_2, PM_{10}, $PM_{2.5}$	Point of max. ground level concentration from traffic emission

		NO_x, PM_{10},	Suburban Industrial/ Traffic
		NO_x, PM_{10}, O_3	Suburban Background
2	Kutaisi	NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, lead, O_3, benzene	Roadside location in Kutaisi
		NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, lead, O_3, benzene	Urban Background location in Kutaisi
		NO_x, CO,PM_{10}, lead, benzene	Suburban Industrial/ Traffic
		NO_x, PM_{10}, O_3	Suburban Background
3	Abkhazia	NO_x, PM_{10}, $PM_{2.5}$, O_3	Rural Background
4	RachaLechkhumiKvemoSvaneti	NO_x, PM_{10}, $PM_{2.5}$, O_3	Rural Background
5	Samegrelo/Guria/Imereti	NO_x, CO, SO2, PM_{10}, PM2.5, lead, O3, benzene	
6	Ajaria	NO_x, PM_{10}, $PM_{2.5}$, O_3, SO_2, PM_{10}, lead, benzene	
7	Samckhe-Javakheti	NO_x, PM_{10}, $PM_{2.5}$, O_3, SO_2, PM_{10}, lead, benzene	
8	ShidaKartli/ Mtskheta-Mtianeti	NO_x, PM_{10}, $PM_{2.5}$, O_3, SO_2, PM_{10}, lead, benzene	
9	KvemoKartli	NO_x, PM_{10}, $PM_{2.5}$, O_3, SO_2, PM_{10}, lead, benzene, CO	
10	Kakheti	NO_x, PM_{10}, $PM_{2.5}$, O_3, SO_2, PM_{10}, lead, benzene	

These recommendations recognize:

- Road transport as the main emissions source of pollution effecting the majority of the Georgian population;
- The potential impacts upon resident populations resulting from pollutants arising from the emissions of point sources to the south east of Tbilisi, the area surrounding Kutaisi as well as Gori and Batumi;
- Fixed, long-term measurements of the pollutants regulated by the CAFE and 4th Daughter Directives have been monitored in part since 2002, though not to the required standards;
- Preliminary measurements of airborne benzene levels in Georgia are, as yet, inconclusive;
- That, given the limited temporal measurement data and lack of surrogate information from emissions inventories, there is little scope to reduce the monitoring burden via supplementary information; and
- A strategic need to characterise roadside, urban background and industrial components of air pollution with a view to improve the quality of input data for modelling purposes and for the development of a national monitoring network and national air quality to begin to improve air quality.

A further recommendation- the commissioning of a rural background monitoring station measuring NO_x, SO_2, PM_{10}, $PM_{2.5}$, ozone and meteorological data is also made with the specific aim of:

- Protecting sensitive ecosystems in Georgia governed by the CAFE Directive;
- Assessment of contributions from transboundary pollution particularly for PM_{10}, $PM_{2.5}$ and ozone;
- To facilitate the development of national plans to improve air quality by identifying components of air pollution which are not directly controllable locally.

The continued broader assessment of Georgia's air pollution is also recommend througha rationalised diffusive sampler surveys, as well as the continued development of domestic and dispersed source emissions inventory.

APPENDIX AMONTHLY CONCENTRATION OF AIR POLLUTANTS MONITORED IN GEORGIA

Figure A1. 2013 February-2014 February average monthly concentrations (μg/m³) of dust measured at Batumi ambient air quality monitoring site

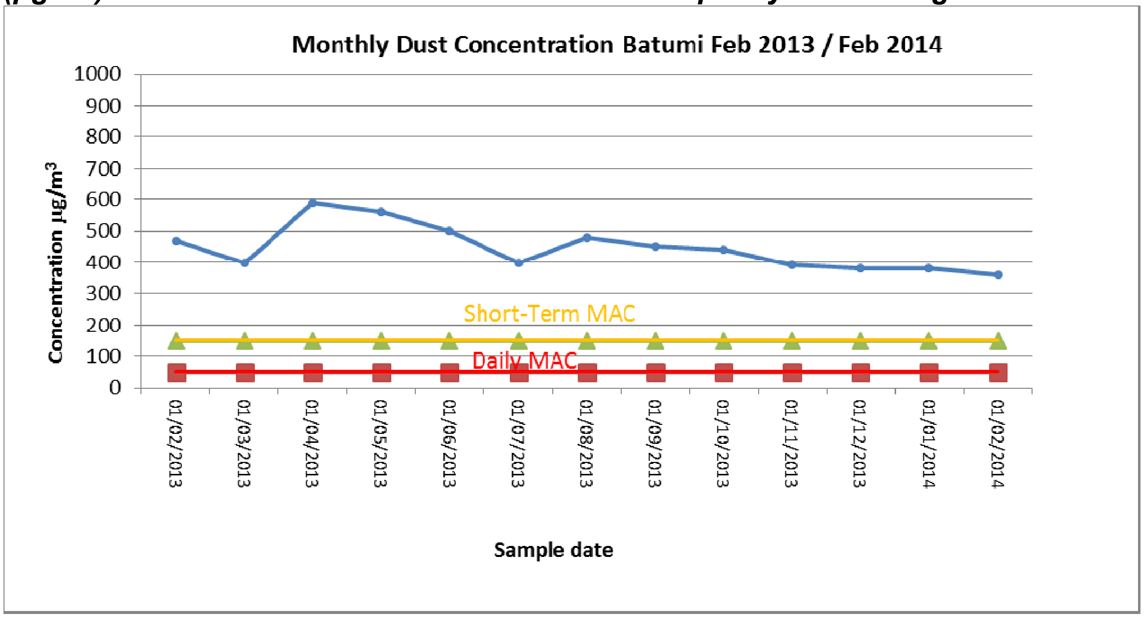


Figure A2. 2013 February-2014 February average monthly concentrations (μg/m³) of CO measured at Batumi ambient air quality monitoring site

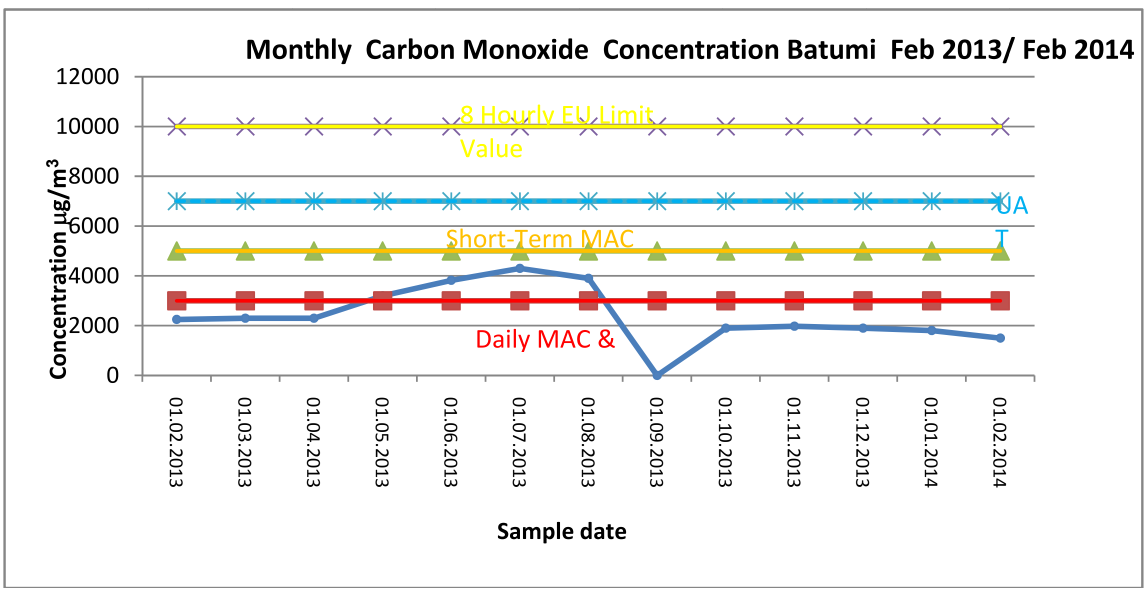


Figure A3. 2013 February-2014 February average monthly concentrations ($\mu g/m^3$) of dust measured at Zestaponi ambient air quality monitoring site

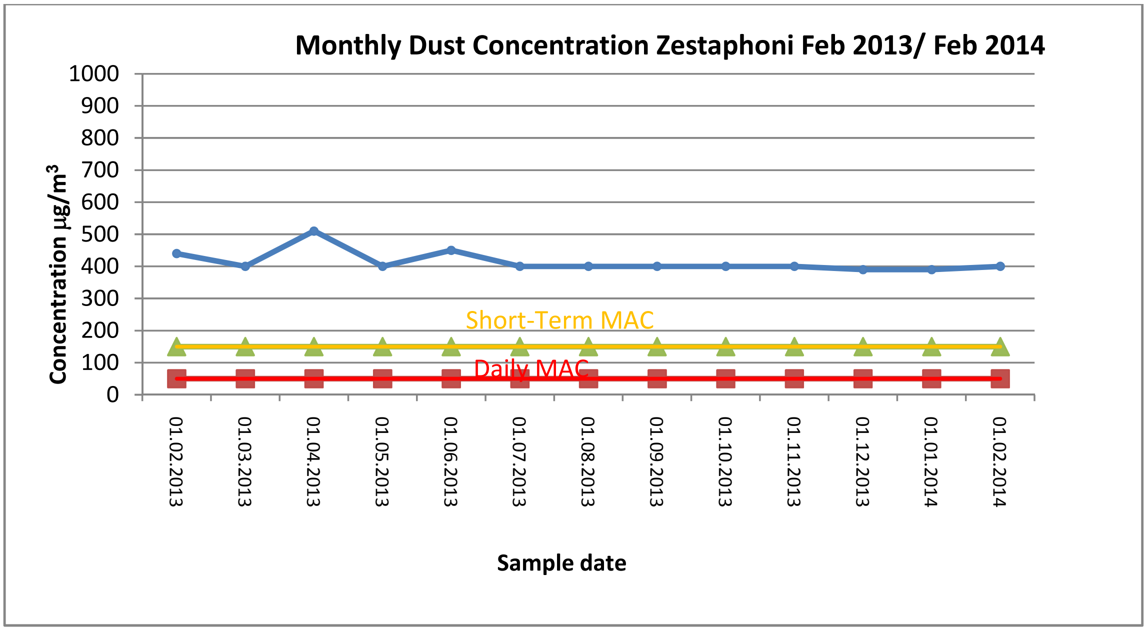


Figure A4. 2013 February-2014 February average monthly concentrations ($\mu g/m^3$) of CO measured at Zestaponi ambient air quality monitoring site

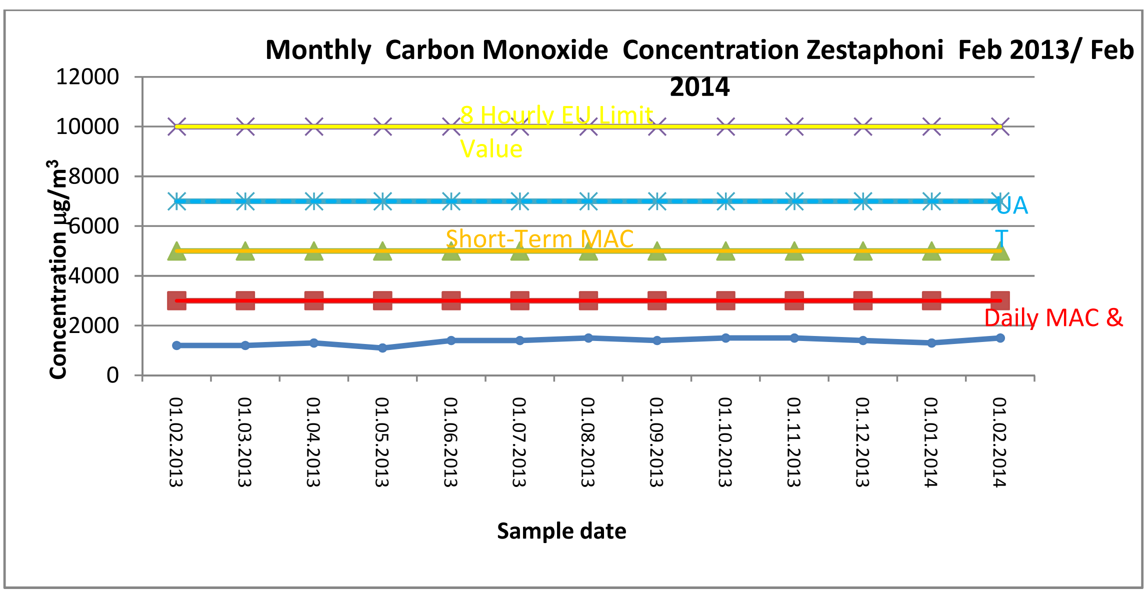


Figure A5. 2013 February-2014 February average monthly concentrations (µg/m^3) of CO measured at Rustavi ambient air quality monitoring site

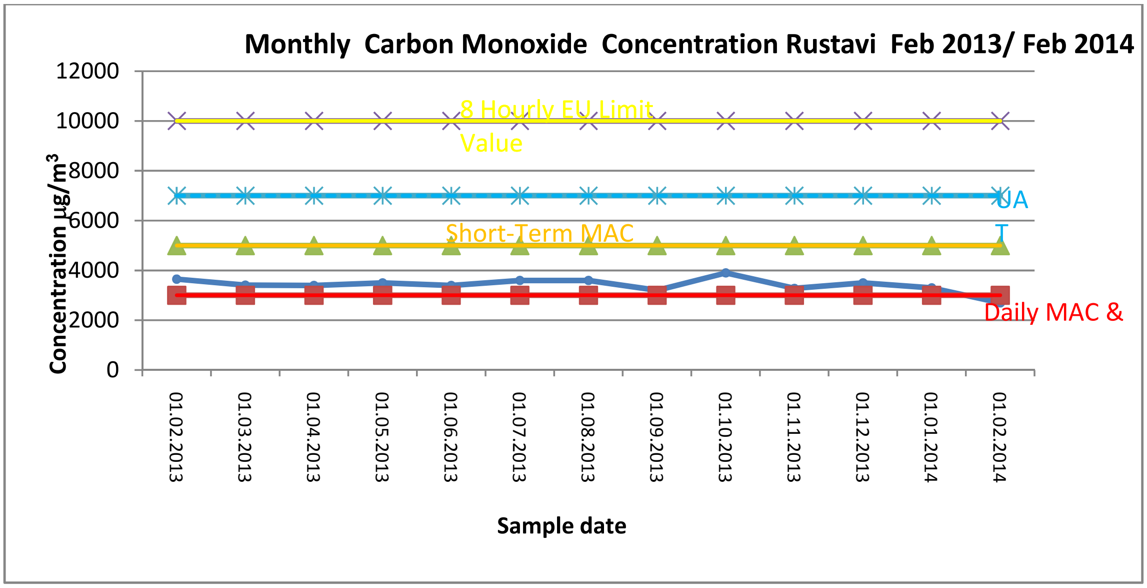


Figure A6. 2013 February-2014 February average monthly concentrations (µg/m^3) of Dust measured at Kutaisi ambient air quality monitoring site

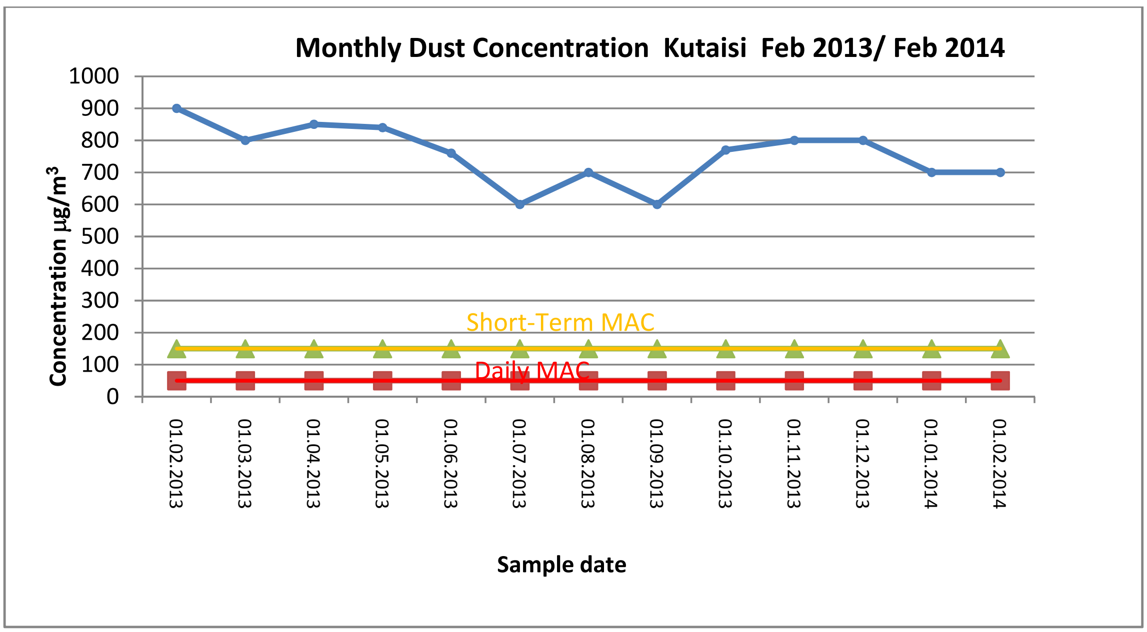


Figure A7. 2013 February-2014 February average monthly concentrations (µg/m³) of CO measured at Kutaisi ambient air quality monitoring site

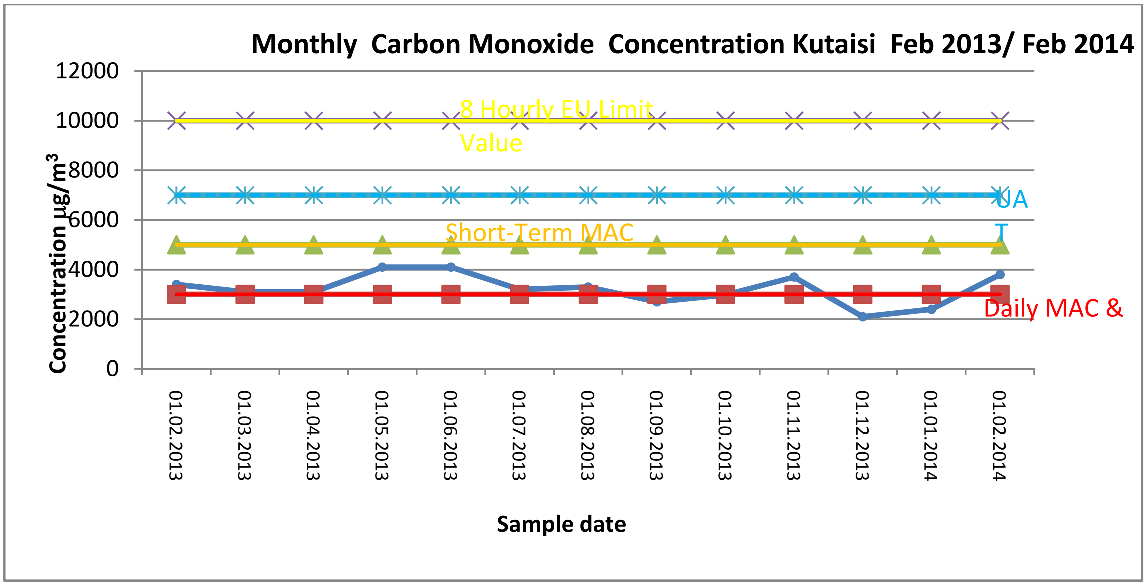


Figure A8. 2013 February-2014 February average monthly concentrations (µg/m³) of dust measured at Tbilisi Kvinitadze street ambient air quality monitoring site Figure 3. 2013

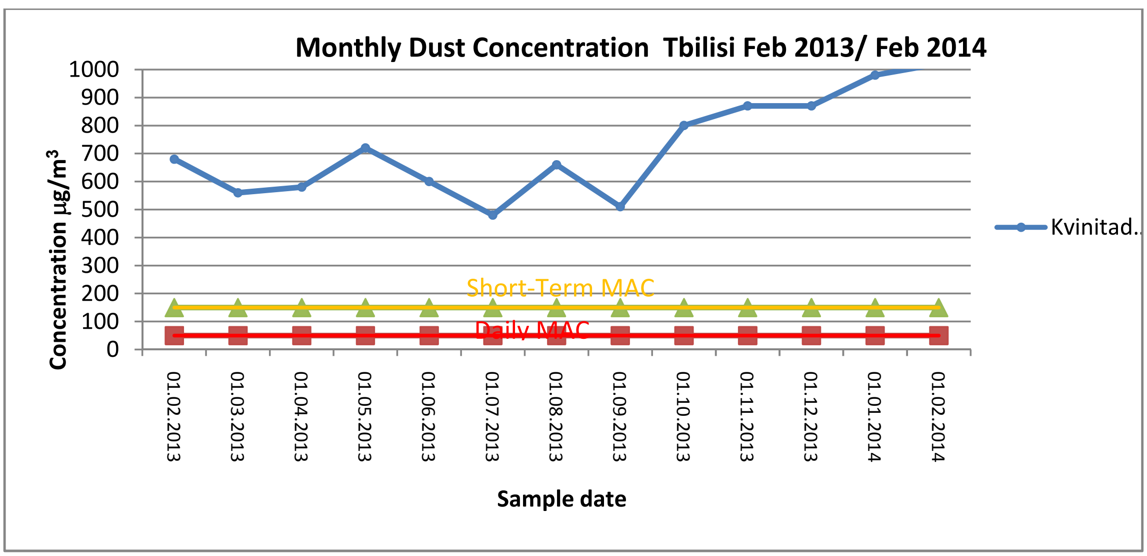


Figure A9. 2013 February-2014 February average monthly concentrations (µg/m^3) of CO measured at Tbilisi Kvinitadze Street and Moscow Ave ambient air quality monitoring site

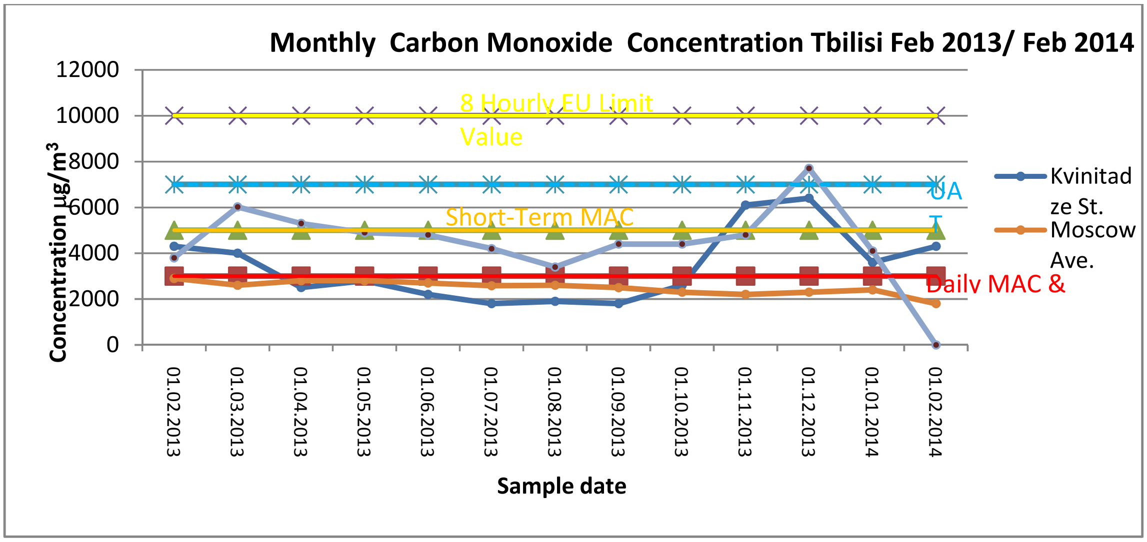


Figure A10. 2013 February-2014 February average monthly concentrations (µg/m^3) of O_3 measured at Tbilisi Kvinitadze Street ambient air quality monitoring site

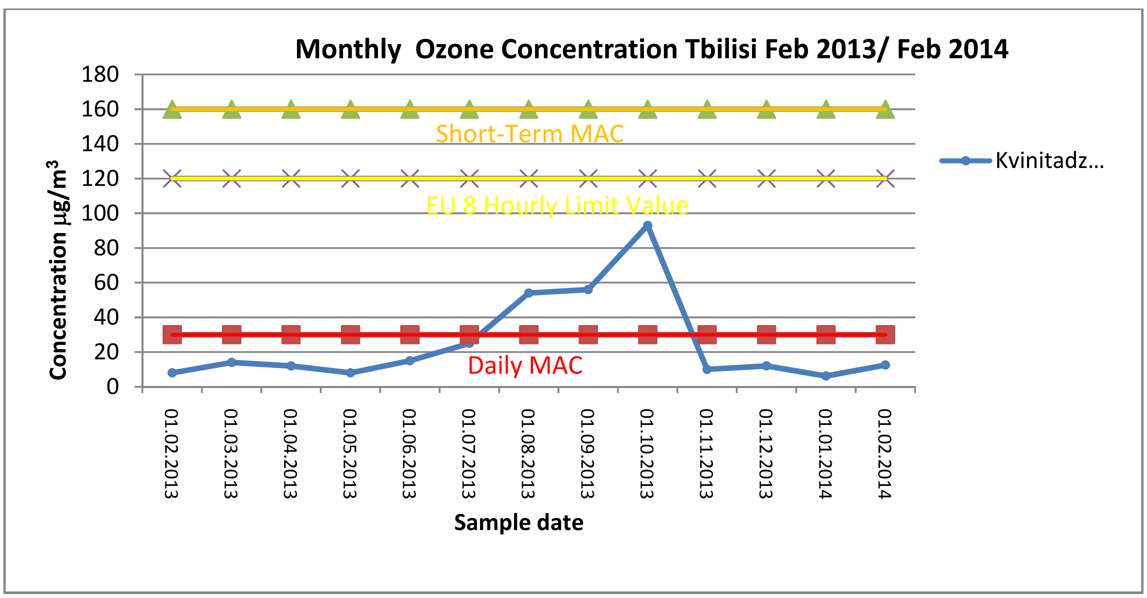
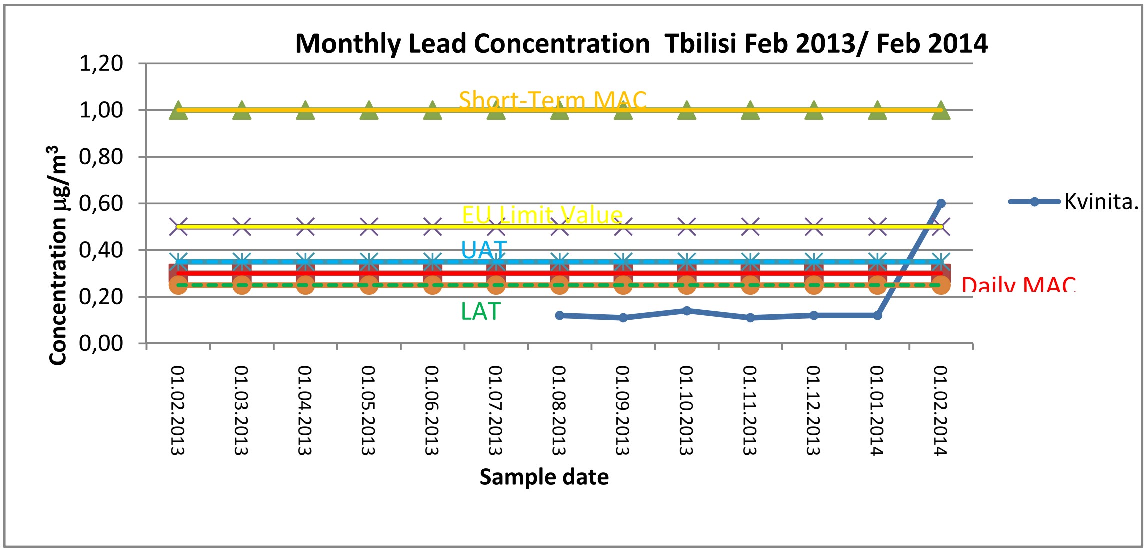


Figure A11. 2013 February-2014 February average monthly concentrations (µg/m3) of Pb measured at Tbilisi Kvinitadze street ambient air quality monitoring site



APPENDIX B PASSIVE SAMPLING RESULTS

City	X and Y Coordinates	Address	Area Description	NO_2 µg/m³	Ozone µg/m³	Benzene
Batumi	719849; 4612655	14 L. Asatianist.	Kerbside	19.10	93.89	
Batumi	719643; 4614603	Rustavelist. - Nearby the theatre	Suburban	68.20		
Batumi	721691; 4613418	55 Maiakovskist. - Terminal building	Urban background	55.73		0.92
Batumi	721265; 4611580	cable car station	Rural	4.02	87.34	
Chiatura	357662; 4683887	next to the sewing building	Urban background	2.98		
Chiatura	358188; 4682838	Chavchavavdzest.	Suburban	7.54		
Poti	721672; 4672834	Entrance of the city - Kokaia alley	Rural	18.50		
Poti	720285; 4670157	Gegidze St.	Industrial			0.85
Poti	721725; 4668489	Snt. Giorgist. and Kolkhetist.	Suburban	8.97		
Poti	721517; 4666965	The end of baratashvilist.	Rural	3.46	94.62	
Kutaisi	307323; 4681624	Next to the Parliament	Roadside	28.58		0.69
Kutaisi	307139; 4679183	Territory of Cemetery	Rural	1.04	160.99	
Kutaisi	308393; 4680643	Chavchavadze Av.	Kerbside	44.55		

Kutaisi	311924; 4682161	D Nidjaradze I st., #1 Kindergarten	Suburban	5.61	81.79	
Zestafoni	335820; 4663667	Chikashua Laboratory	Suburban	6.51	62.59	
Zestafoni	335802; 4664901	"Saqkabeli"	Industrial	50.19		
Zestafoni	337276; 4663552	Agmashenebelist.	Urban	31.85		
Zestafoni	338321; 4662795	55 Machavarianist.	Suburban	8.68	92.32	
Zestafoni	333006; 4661608	village Kvaliti	Rural	3.41	75.44	
Tbilisi	486584; 4613880	Tbilisi 14	Kerbside	51.72		
Tbilisi	486774 ; 4614183	Tbilisi 29	Kerbside	31.63		
Tbilisi	0482534;1618410	Agmashenebeli St.	Kerbside	38.10		
Tbilisi	0482582;4619181	Tseretelist.	Kerbside	36.15		
Tbilisi	0482982;4618952	Suramist.	Urban background	38.66		
Tbilisi	0482968;4620078	Dadiani St.	Urban background	24.68		
Tbilisi	0481914;4620935	Stanislavski st.	Urban background	31.16		
Tbilisi	0479171;4618706	Budapestist.	Urban background	47.58		
Tbilisi	0481150;4618825	Bakhtrionist.	Urban background	37.04		

Tbilisi	0479171;4618706	Hippodrome	Road side	27.21		
Tbilisi	0479016 ;4619419	VashaPshavela Av.	Road side	27.13		
Tbilisi	0482824;4618209	Agmashenebeli Av.	Road side	59.36		
Tbilisi	0483058; 468041	Tolstonokovist.	Urban background	46.65		
Tbilisi	0481285;4623607	G. Gogiberidzest. Park	Urban background	12.70		
Tbilisi	0479985;4627009	Tavdadebulistr and Petritsist.	Road side	14.53		
Tbilisi	0484569 ;4627018	Gldani district. Mosulishvilist. Park	Kerbside	26.98		
Tbilisi	0485298;4626981	Mosulishvilist. School #79 area	Suburban	33.74		
Tbilisi	0485260;4624823	Temqa district	Urban background	24.50	70.46	
Tbilisi	043678; 4624702	Chargalist.	Urban background	44.84		
Tbilisi	0483280;4624997	Shatilist.	Urban background	22.76		
Tbilisi	0476986;4618521	University - Maglivi building	Urban background	17.69		
Tbilisi	483497; 4615710	Freedom Sq.	Kerbside	59.17		
Tbilisi	483113; 4616166	1st School	Kerbside	42.14		
Tbilisi	482494; 4617004	Rustaveli Av.	Kerbside	94.03		

Tbilisi	482502; 4617274	Leo Kiachelist.	Road side	53.25		
Tbilisi	482161; 4617409	Kostavast.	Road side	80.78		
Tbilisi	480938; 4617301	Abashidzest.	Suburban	51.68		
Tbilisi	480268; 4617690	ZurabArakishvilist.	Urban background	51.16		
Tbilisi	479447; 4616434	Turtle lake	Suburban	9.57		
Tbilisi	481163; 4617828	Mziuri Park	Roadside	29.67		
Tbilisi	481825; 4617435	Melikishvili av.	Urban	70.60		
Tbilisi	494172; 4612152	BesarionChichinadzest.	Suburban	19.19		
Tbilisi	496457; 4615873	Lilo settlement	Suburban	14.37		
Tbilisi	488119; 4615605	DimitriUznadzisst.	Urban background	34.28		
Tbilisi	4876105;4616510	TeopaneDavitianist.	Suburban	28.37		
Rustavi	497954; 4601590	Rustavi 1	Kerbside	14.08		
Rustavi	498474; 4602342	Rustavi 2	Sub urban	14.89		
Rustavi	501619; 4597497	Rustavi 3	Industrial	16.76		
Rustavi	503900; 4595427	Rustavi 5	Industrial	20.32		

Rustavi	504560; 4597282	Rustavi 6	Industrial	17.77		
Rustavi	506989; 4602169	Rustavi 7	Rural	9.34	111.35	4.03
Rustavi	508572; 4598787	Rustavi 4	Industrial	16.76		