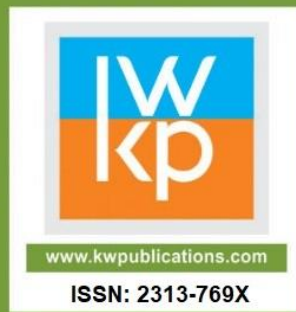


# INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ENVIRONMENT & GEOGRAPHY



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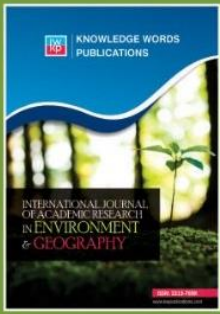
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## Management of Greenhouse Gases Emissions in the Current Climate Change: Case Study: Center Region, Romania

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### Abstract

This study addresses climate changes issue related to greenhouse gases emissions. Earth suffered in time a series of major changes in climate and we are now in a process of gradual warming, which can have devastating consequences. It is now accepted that greenhouse gases produced by human activities, but not only, are the main cause of this issue because of their high global warming potential. Scientific studies have shown that the substances that act as greenhouse gases adsorbing and emitting infrared radiation are: water vapors (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxides (N<sub>2</sub>O), ozone (O<sub>3</sub>) and Chlorofluorocarbons (CFC). The study took into account the climate changes that occurred for processing sets of relevant statistical indicators, in order to analyze and identify appropriate solutions to decrease the impact of greenhouse gas emissions. Have been analyzed the main aspects of the quantity of greenhouse emissions, during 2003-2010, released into the atmosphere both at the global level: in the Romanian Center Region and at local level: in counties of the region. Through processing data obtained from environmental reports, studies and specific documents were formulated conclusions that can be useful in proposing measures and action plans for reducing emissions of greenhouse gases.

**Keywords:** Climate Changes, Greenhouse Gases, Global Warming.

### Introduction

In the present study have been reviewed the main issues regarding the amount of GHG emitted into the atmosphere during 2003 – 2010, in the Romanian Center Region and in the counties of this region (Alba, Brasov, Covasna, Harghita, Mures and Sibiu). The GHG released into the atmosphere during 2003 – 2010 in the Center Region, the highest percentages is

carbon dioxide (CO<sub>2</sub>) – 69 %, nitrogen dioxide (N<sub>2</sub>O) – 22 % and methane (CH<sub>4</sub>) – 9 %. In order to reduce CO<sub>2</sub> emissions by the analysis attempts to identify appropriate solutions to maintain a balance between environmental fragility and the tendency of economic development and prosperity is directly proportional to the depletion of non-renewable resources at regional level.

### Materials and Methods

On January 22, 2014, the European Commission proposed to reduce greenhouse gas emissions by 40% by 2030 compared to current target of 32 %, thus enhancing efforts to combat climate change. All efforts made to date to reduce global emissions of greenhouse gases (GHG) and all the scientific studies developed in this purpose show that in the next period the average global temperature will continue to increase, therefore is urgent to implement adequate measures in response to climate change.

For policy makers at international level, global warming raises two major concerns:

- need to significantly reduce emissions of GHG in order to reduce human influence on the natural climate system;
- need to promote policies and measure to adapt to foreseeable effects of climate change, mainly due to the inertia of the climate system.

Climate change is caused directly or indirectly by human activities, which results in changing the composition of the global atmosphere and which is added to natural climate variability observed over comparable time period. Can be observed climate change caused by human activities that produce emissions of GHG (greenhouse gas emissions set by the Kyoto Protocol). Less than 1% of the earth's atmosphere is made up of water vapor (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), ozone (O<sub>3</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) and sulfur hexafluoride (SF<sub>6</sub>) gas known as (GHG).

Environmental structural indicator “total emissions of greenhouse gases” means the amount in tons/year of pollutants that are regulated by the Kyoto Protocol. In order to compare the impact on the environment in terms of "climate change" has different GHG emissions because warming potential differs from gas to gas, international experts have agreed to use the term CO<sub>2</sub> equivalent (CO<sub>2</sub>eq) using equivalence factors that relate to warming potential. Factors equivalence between GHG and CO<sub>2</sub> are defined for a given period of time (20, 100 or 500 years) and are regularly updated by the IPCC references. Equivalence describes, for a given mixture and amount of gas, the same heating potential W/m<sup>2</sup> - ("global warming potential" = GWP) when measurements refer to a certain period of time (usually 100 years). Thus, the overall potential of the gases (PGE) is expressed as a CO<sub>2</sub> equivalent, CO<sub>2</sub> having by definition PGE 1, N<sub>2</sub>O having the same value multiplied by 310 and CH<sub>4</sub> multiplied by 21. In table 1 are presented the main GHG contribution to the global warming.

**Table 1. The main GHG contribution to global warming**

Gas	Chemical formula	Contribution %
Water vapors	H <sub>2</sub> O	36 – 72
Carbon dioxide	CO <sub>2</sub>	9 – 26
Methane	CH <sub>4</sub>	4 – 9
Ozone	O <sub>3</sub>	3 – 7

Source: IPCC list – www.ipcc.ch

Among the pollutants by the Kyoto Protocol, in Romania are inventoried emissions of carbon dioxide, nitrogen oxides and methane, being in perspective to perform an inventory with also other gases included in the protocol, such as: sulphides, hexafluorids, hydrofluorocarbons and perfluorocarbons (list IPCC), nitrogen trifluoride (unlisted), which has a significant global warming potential but may be present in very small quantities.

## Results and Discussion

Greenhouse gases presence in the atmosphere are a natural phenomenon of extreme importance to life on Earth. Certain gases in the atmosphere behave like glass walls of a greenhouse retain part of the infrared radiation (heat) reflected from the surface of planet Earth and maintains a temperature high enough to sustain life. Physical and chemical processes involved allow maintaining temperature in the lower layers of the atmosphere, at an average around 15 °C. In the absence of these processes, the average temperature at the soil surface would be -18 °C, which would lead to the disappearance of all forms of life.

Global warming is a phenomenon widely accepted by the international scientific community, already highlighted by the analysis of observational data over long periods of time. Simulations carried out using global climate models indicate that the main factors behind this phenomenon are both natural (changes in solar radiation and volcanic activity) and anthropogenic (changes in the composition of the atmosphere due to human activities).

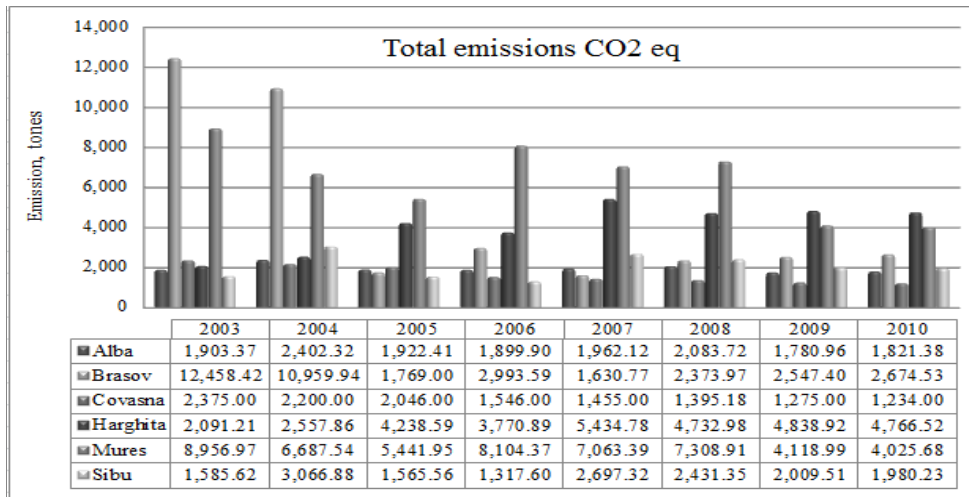
In this study we have analyzed the main issues regarding the amount of GHG emitted into the atmosphere during 2003 – 2010 in the Center Region (Romania – Figure 1) as a whole and in the constituent counties (Alba, Brasov, Covasna, Harghita, Mures and Sibiu), specifying the fact that were taken into account only those areas in the region that have been polluted with GHG.

Based on environmental reports released by the Environmental Protection Agencies of the Centre Region counties it was observed that in recent years air quality played an important role. Air quality monitoring is an useful tool which provides direct information on the actual situation in an important segment of the urban environment.



Source: our processing Open Source GIS  
**Figure 1. The Center Region, Romania**

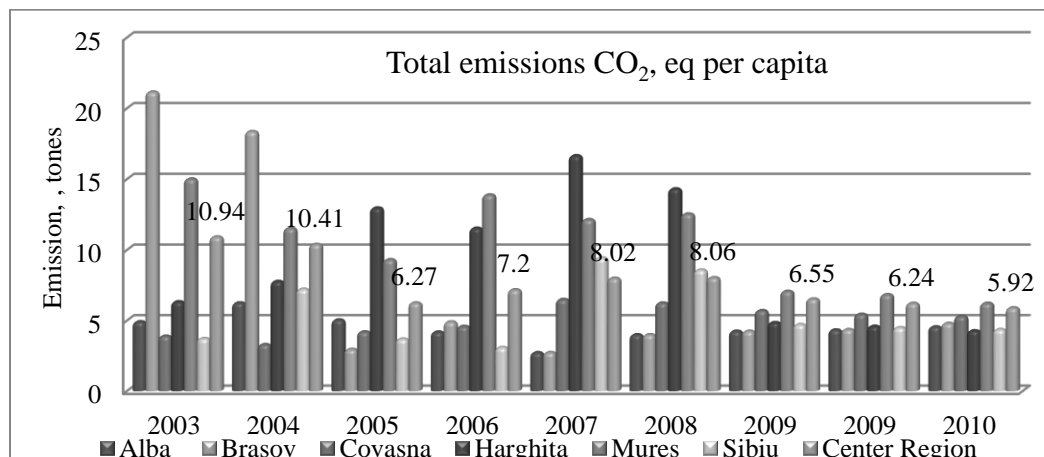
Figure 2 emphasizes a sharp decrease in GHG emissions since 2005 and steadily decreased from 2007 to 2010 in all counties of the Center Region.



Data source: Environmental Protection Agency Sibiu

Figure 2. Equivalent CO<sub>2</sub> emissions in the counties of Center Region, during 2003–2010

A relevant indicator in the analysis of pollution and its effects is the amount of total annual emissions of GHG relative to the total number of inhabitants. Thus, mathematical methods can determine the amount of total emissions of GHG per capita quantity in tons/capita (Figure 3).



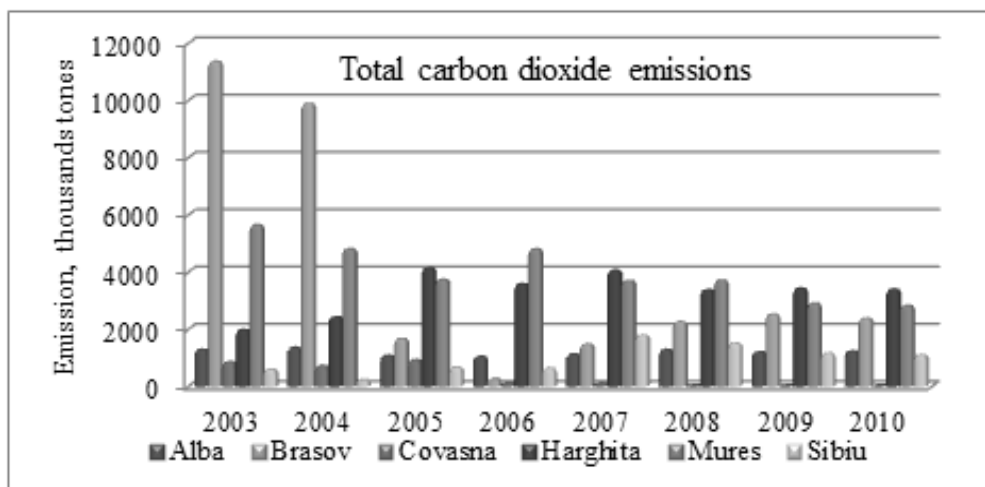
Data source: Environmental Protection Agency Sibiu

Figure 3. Equivalent CO<sub>2</sub> emissions per capita in the counties of Center Region, during 2003–2010

### Annual Emissions of Carbon Dioxide (CO<sub>2</sub>)

The main sources of CO<sub>2</sub> emissions are the combustion in the energy sector, and non-industrial combustion plants, combustion in manufacturing industry, and emissions from road transport. An in-depth analysis of the numerical values of total CO<sub>2</sub> emissions in the period

2003 – 2010 can be used in forecasting the global warming phenomena that implies climate changes (increases in the average annual air temperature, increased thunderstorm phenomena etc.). In the period 2003 – 2004 in Brasov was recorded the largest amount of CO<sub>2</sub> emissions, as being 21,272.910 tons. There are positive cases, which are within normal limits. For example, in Covasna county, for a period of three years (2007 – 2009) the total amount of CO<sub>2</sub> was below 100.000 tons (Figure 4).



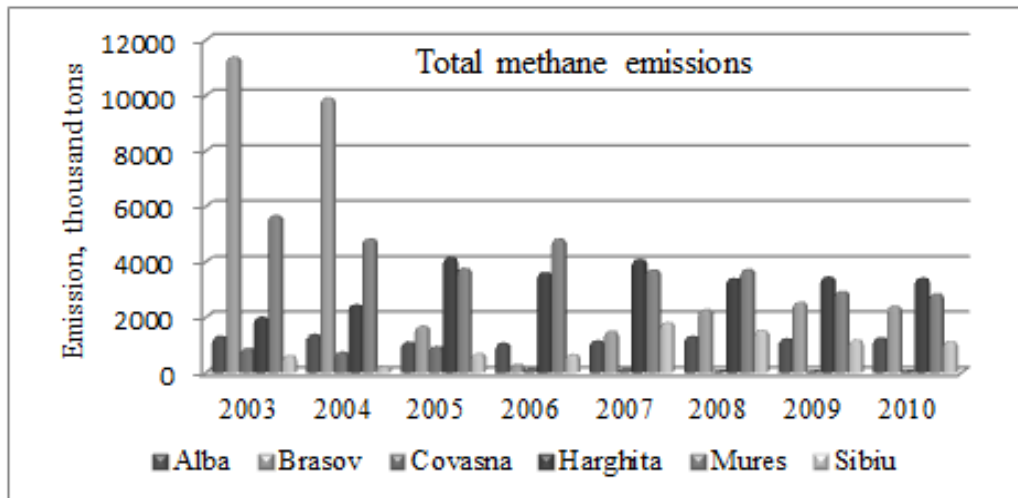
Data source: Environmental Protection Agency Sibiu

**Figure 4. CO<sub>2</sub> emissions in the Center Region counties**

#### Annual Emissions of Methane (CH<sub>4</sub>)

According to the annual environmental reports elaborated by the Regional Environmental Protection Agency Sibiu, environmental structural indicator "total annual emissions of methane" the total emission is mainly obtained from agriculture (fermentation) and forestry.

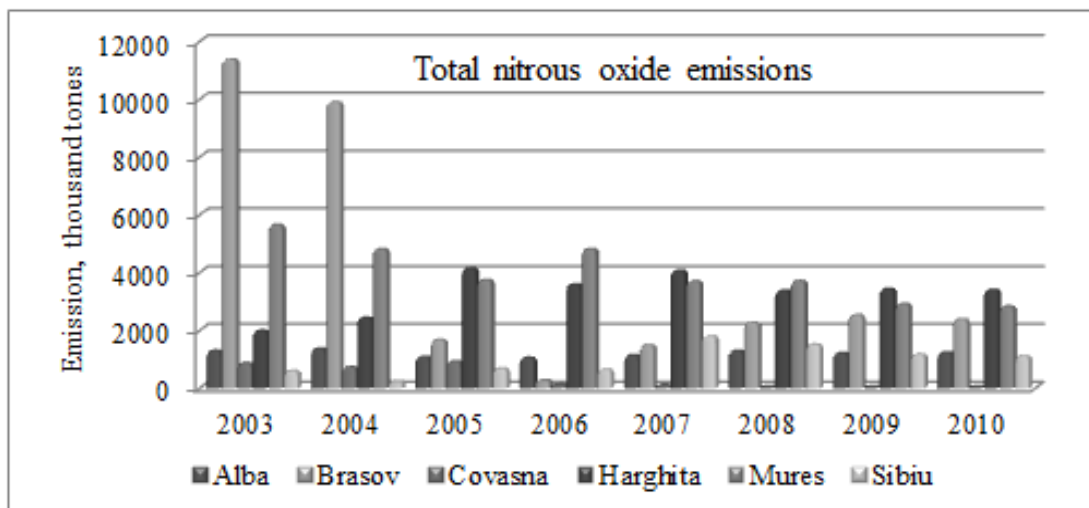
The analysis of data from the counties for the past 7 years shows significant differences in the amount of methane released into the atmosphere (Figure 5). Values less than 5,000 tons per year of methane were recorded in Brasov (2003 – 2010), Alba (2009 and 2010), Covasna (2003 – 2007), and Harghita County (2003 – 2004). Worrying values of annual emissions of methane, more than 50 thousand tons/year, were recorded in the same county (2003 – 2004, 2006 – 2008).



Data source: Environmental Protection Agency Sibiu  
**Figure 5. CH<sub>4</sub> emissions in the Center Region counties**

### Annual Emissions of Nitrous Oxide (N<sub>2</sub>O)

Nitrous oxide is emitted mainly from agriculture and forestry activities. In figure 6 it can be seen a steady increase in nitrous oxide emissions since 2005, the increase being influenced by emissions from SC Azomureş (Mures County) and increased fleet, but since 2009 due to reduced activity in SC Azomureş and other companies, there is a significant decrease in nitrous oxide emission values.



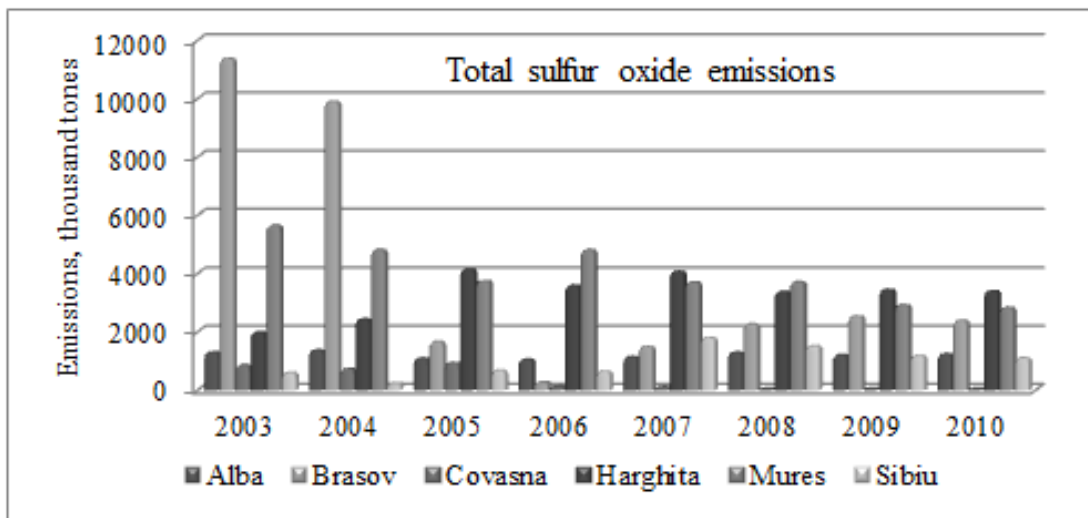
Data source: Environmental Protection Agency Sibiu  
**Figure 6. N<sub>2</sub>O emissions in the Center Region counties**

### Annual Emissions of Sulfur Dioxide (SO<sub>2</sub>)

The highest levels of SO<sub>2</sub> emitted into the atmosphere are caused by energy production (combustion of fossil fuels) from, road transportation, and emissions from non-industrial combustion plants and combustion in manufacturing.

In figure 7 it can be observed that the evolution of annual emissions of sulfure dioxide reached the maximum value 2003, following a continuous decline until 2007. In addition to

emissions from traffic sources in the Center Region of SO<sub>2</sub>, largest contribution comes from SC SOMETRA SA (Sibiu) must implement Flue Gas Desulfurisation FGD by 2011, this explains the increase in concentration of SO<sub>2</sub> emissions. Decrease in 2009 is due to the fact that the above mentioned company activity ceased. At county level, the largest sources of SO<sub>2</sub> are in Brasov and Sibiu, their intense activity being registered in 2001 – 2002 and 2007 – 2008.



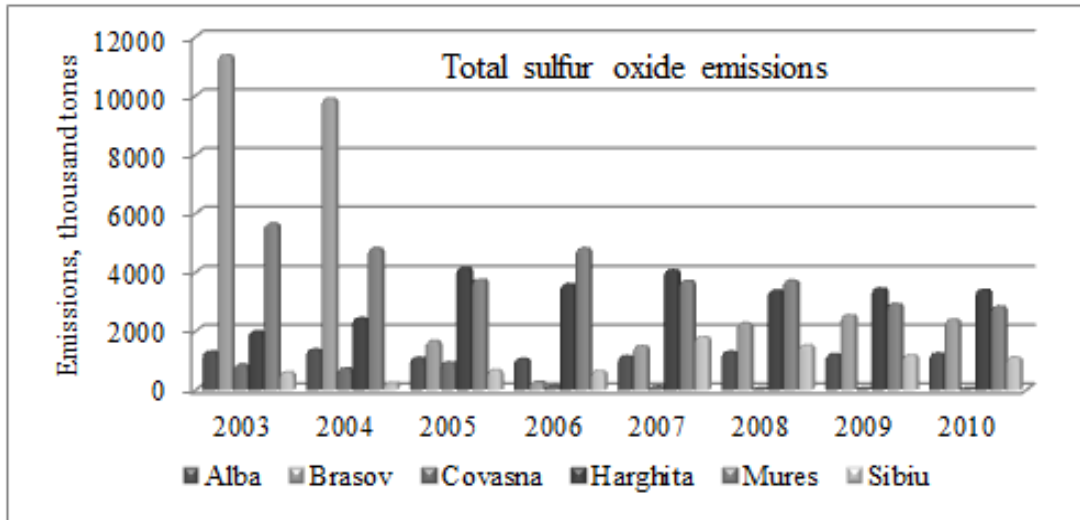
Data source: Environmental Protection Agency Sibiu

Figure 7. SO<sub>2</sub> emissions in the Center Region counties

#### Annual Emissions of Nitrogen Oxides (NO<sub>x</sub>)

Nitrogen oxides are resulting from combustion of fuels in stationary and mobile sources and industrial or biological processes. Nitric oxide is a colorless gas, resulting from the combination of nitrogen and oxygen directly at high temperatures. By analyzing the graph, comparing the period 2002 – 2006, it can be observed a major decline in emissions of nitrogen dioxide (Figure 8), which is mainly due to the implementation of environmental legislation for the protection of the atmosphere. The largest amounts of nitrogen oxides were emitted into the atmosphere in 2007 – 2008, the leading sources being located in Brasov and Alba counties.

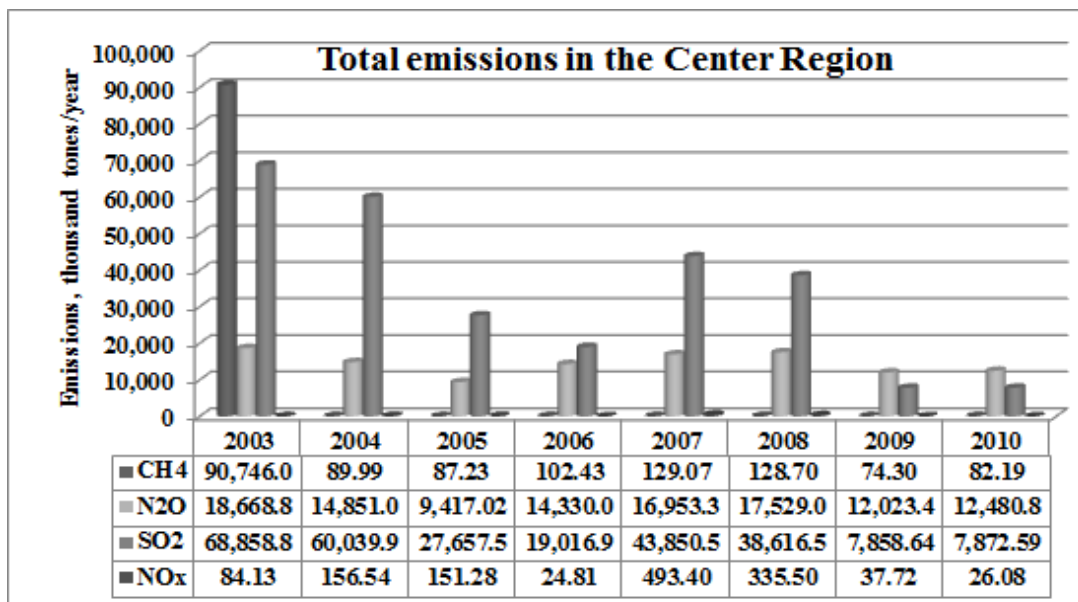




Data source: Environmental Protection Agency Sibiu

Figure 8. NO<sub>x</sub> emissions in the Center Region counties

Significant reduction of GHG emissions since 2009 can find its explanation in less economic activity as a consequence of the financial crisis. Quantifying the amounts of GHG based on statistical processing of data obtained from the Regional Environmental Protection Agency Sibiu, in 2009, was recorded a sum of 8,625,369.876 tons/year GHG emissions in the Center Region (Figure 9).



Data source: Environmental Protection Agency Sibiu

Figure 9. Total emissions in the Center Region

In the present study were considered emissions of GHG: carbon dioxide, methane, nitrous oxide, sulfur dioxide and nitrogen oxides expressed in tons/year. Data on emissions of GHG were gathering considering as pollution sources the following sectors: industry,

agriculture, non-industrial combustion plants, residential facilities, transport, and stationary mobile sources (Tables 2 and 3).

**Table 2. Amount and share of emissions of GHG in the Center Region in 2010**

Indicators calculated	Values (tons/year)	Percentage (%)
Total CO <sub>2</sub> emissions	8,625,369.876	97.066
Total CH <sub>4</sub> emissions	149.257	0.168
Total N <sub>2</sub> O emissions	8,855.104	0.1
Total SO <sub>2</sub> emissions	23,040.177	0.259
Total NO <sub>x</sub> emissions	213,873.845	2.407
Total GHG emissions	8,886,065.259	100

Data source: Environmental Protection Agency Sibiu

**Table 3. Amount and share of emissions of GHG in the Center Region in 2009 by activity sectors**

Indicators calculated	Values (tons/year)	Percentage (%)
Total GHG emissions in industry	3,083,785.24	34.704
Total GHG emissions in agriculture	2,159.777	0.024
Total GHG emissions in non-industrial combustion plants	228,604.93	2.573
Total GHG emissions from residential combustion plants	4,049,395.02	45.57
Total GHG emissions in transport	1,131,635.97	12.735
Total GHG emissions from stationary power sources	390,484.332	4.394
Total emissions of GHG	8,886,065.26	100

Data source: Environmental Protection Agency Sibiu

From total amount of GHG in the Center Region the largest amount is attributed to carbon dioxide emissions: 97.066 %. Looking at the share of GHG emissions by activity sectors, it was found that the highest regional percentage is represented by emissions from residential combustion plants (45.570 %) followed by industry (34.704 %) and transport (12.735 %).

Based on data obtained from the monitoring of GHG emissions have been observed high risk events within the Center Region where the MAC (maximum quantity admitted) was exceeded. These areas are Copşa Mica (SO<sub>2</sub>) and Brasov (NO<sub>x</sub>). In addition to the risks of the main components of environmental compartments, GHG may pose a high risk to the health of people living in the affected areas. In most cases, the direct effect of air pollution on health is the result of interaction of several pollutants simultaneously present in the atmosphere.

In the Center Region, the share of GHG with adverse health impacts can be associated to their irritant effect (SO<sub>2</sub>, NO<sub>x</sub>, ozonides) in Alba, Sibiu and Mureş.

Based on observation of weather and climate phenomena of recent years in the geographical area of the Center Region can be stated that:

- ✓ increased frequency of thunderstorms phenomena (storms, hail, lightning etc.), especially in summer;
- ✓ decreased amount of annual rainfall in certain geographic areas, which determines the appearance or intensification of droughts;
- ✓ increases in average monthly temperature in all seasons;
- ✓ decreased number of days with snow in winter especially in the plateau, valleys;
- ✓ for certain steps hypsometric agriculture was affected by changing the zoning of crops.

### Conclusions

In the past 30 years, Romania is experiencing the effects of frequent droughts at a larger spatio-temporal scale. Regional and local climate change will affect both biotic and abiotic compartments, posing a serious threat to human life. Occurrence of extreme hydrological and meteorological phenomena such as heat waves, floods and droughts, has the effect of both environment and life and significant economic losses in all sectors (agriculture, transport, energy supply, water management etc.). Unfortunately, the global climate models indicate that the frequency and intensity of these events will increase in the next period. Economic development in recent years has been associated to several effects on the environment and human health due to the quality of air, water, soil etc. There were identified certain sectors that influenced directly the increase of CO<sub>2</sub> emissions in the Center Region of Romania: energy industry, metallurgy, chemical industry and transport. Therefore, the studies conducted identified several measures to reduce GHG emissions, in the Center Region:

- ✓ change fuel energy production facilities or industrial facilities, use of low carbon fuels;
- ✓ changing the ratio between "green energy" and conventional energy;
- ✓ rehabilitation and improvement of power plants groups;
- ✓ shares afforestation and/or reforestation;
- ✓ more efficient energy processes;

Expansion of green spaces - through national programs to improve environmental quality through green spaces in towns.

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