

CO₂ EMISSION INVENTORY FOR TURKEY

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ABSTRACT

It is an observational fact that atmospheric carbon dioxide (CO₂) is increasing and will continue to increase in the future. The increase of CO₂ concentration in the atmosphere is mainly formed from combustion of fossil fuels for the generation of energy. Together with CO₂ many other pollutants may be generated. However, CO₂ cannot be removed like other pollutants and it causes greenhouse (GH) effect and ultimately climate change.

In this study, CO₂ emission data for the year of 1995 to 2000 from the households, manufacturing industry, thermal power plants and road vehicles were calculated for all 910 districts of Turkey and this has been investigated by using Geographic Information System (GIS) techniques. Using GIS programs in the paper according to the emission sources formed scaled emission maps. The CO₂ emission inventory was prepared by considering the total amount of fuels used in provinces with respect to sources, then this inventory was linked to the GIS mapping of provinces. The emission of CO₂ was calculated by using the IPCC-Tier 1 method.

The result of this study shows that for the year of 1995, the maximum households' emission was observed in Bakırköy and Kartal districts of İstanbul province with 2.6 and 1.3 million ton/year. The maximum CO₂ emission from the Road vehicles also occurred in Bakırköy. The emission was around 1.1 million ton/year. The highest industrial emission was observed in İskenderun district of Hatay province and Eregli district of Zonguldak province with 5.9 and 5.2 million ton/year, respectively. Afsin-Elbistan Power Plant in K.Maraş province emitted 6.2 million ton/year, which was the maximum emission rate among the power plants. In 2000, the maximum households' emission was again observed in Bakırköy and Kartal districts with 3.3 and 1.6 million ton/year and the maximum industrial emissions were also observed at the same places (İskenderun and Egreli districts) with respective values of 6.8 and 4.7 million ton/year. However, Soma Power Plant in Muğla province took the place of Afsin-Elbistan Power Plant in 2000 and emitted the highest emission with the value of 6.3 million ton/year. The highest CO₂ emission district and rate of Road vehicles was not altered for the year of 2000.

Key Words: GIS Techniques, Inventory, CO₂ Emission, IPCC - Tier 1 Method.

INTRODUCTION

It is an observational fact that atmospheric CO₂, which is formed during the generation of energy, is increasing and will continue to increase in the future [2; 13]. The increase of CO₂ concentration in the atmosphere derived from global sources over time is due to its long life in the atmosphere [4]. The industrial revolution has been considered as the beginning of the

growth of the CO₂ concentration through the years [1]. This pollutant is emitted into the atmosphere due to combustion of fossil fuels and land-use changes [7]. The global CO₂ budget is complex and involves transfer of CO₂ between the atmosphere, the oceans and the biosphere [3]. It is estimated that CO₂ concentration is responsible for about 60% of the greenhouse effect [10; 12]. However, CO₂ cannot be removed like other pollutants and it causes ultimately climate change [6].

The purpose of this study was to investigate the CO₂ Emission Inventory of Turkey by using Geographic Information System (GIS) techniques [5; 8; 9; 14]. All 910 districts in Turkey have been considered in this study. The necessary data were obtained from the inventories of the State Institute of Statistics, Ministry of Energy and Turkish Electricity Generation – Transmission Corporation. In this study scaled maps were prepared by using GIS software. The inventory was linked to the GIS mapping of districts' zone and provincial area. The CO₂ Emission was calculated by using the IPCC-Tier 1 method [7].

METHODOLOGY

Simple method (IPCC - Tier 1) was used to estimate the CO₂ emissions. The estimation process can be divided into some steps that lead to figures for CO₂ emissions from fuel consumption. The general formula for the CO₂ emission is given as [7; 11]:

$$\text{CO}_2 \text{ emissions} = \sum \text{Fuel consumption in energy units (TJ) for each sector} * \text{Carbon Emission Factor} * \text{Fraction Oxidized} * \text{Conversion of Emission of Carbon to CO}_2.$$

RESULT AND DISCUSSION

The result of this study showed that the CO₂ emission over Turkey has been increasing throughout the years. To emphasize, about 200 million ton CO₂ was emitted into the atmosphere from Turkey each year (Figure 1).

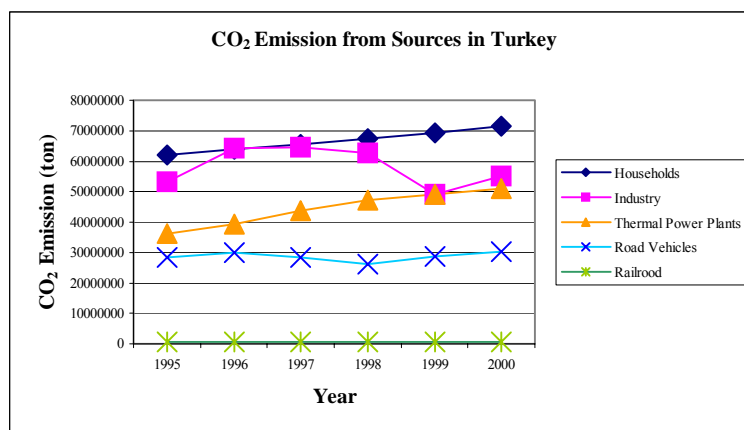


Figure 1. The CO₂ emission from various sources between 1995 and 2000.

The emission trends of households and thermal power plants showed an increase rarely and reached their maximum values 69 million ton/year and 49 million ton/year respectively in 2000. On the other hand, for road vehicles the trends of emission was around 28 million ton/year and for railroad, it was 0.7 million ton/year between the base years. The industrial emission trend, in difference, showed a fluctuation, and reached its maximum value 64 million ton/year in 1997. In general amongst the years, the percentage of the emission from households and manufacturing industry were the highest with the approximate values 35% and 30% in sequence.

Regional Variations:

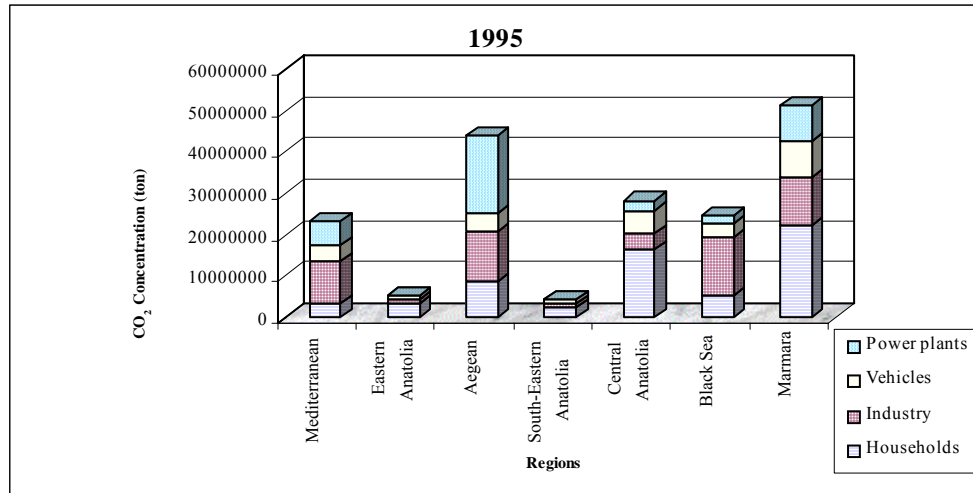


Figure 2. The regional CO₂ emission from various sources in 1995.

The Regional Emission was changing as seen in the Figure 3. and 4. In 1995, the maximum CO₂ emissions were from the Marmara Region (51 million ton/year), Aegean Region (44 million ton/year), Central Anatolia (28 million ton/year), Black Sea Region (24 million ton/year) and Mediterranean Region (23 million ton/year) respectively. The minimum CO₂ emissions were from the Eastern Anatolia (5.4 million ton/year) and South- Eastern Anatolia (4.5 million ton/year). The CO₂ emission rate was almost the same in 2000.

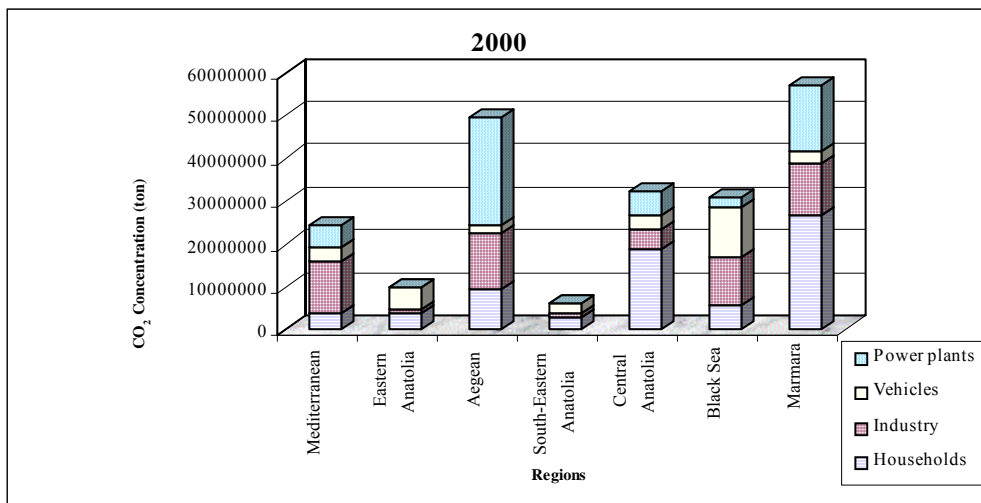


Figure 4. The regional CO₂ emission from various sources in 2000.

Provincial and Local Variations:

In Turkey, the annual CO₂ emission according to the sources was changing for each district and in each year as seen in the above figures. The maximum households' emission was observed in Bakirköy and Kartal districts of İstanbul province with 2.6 and 1.3 million ton/year in 1995 and with 3.3 and 1.6 million ton/year in 2000. The provincial maximum emission was seen in İstanbul with 12.5 million ton/year CO₂ in 1995 and with 15.5 million ton/year CO₂ in 2000 (Figure 5.).

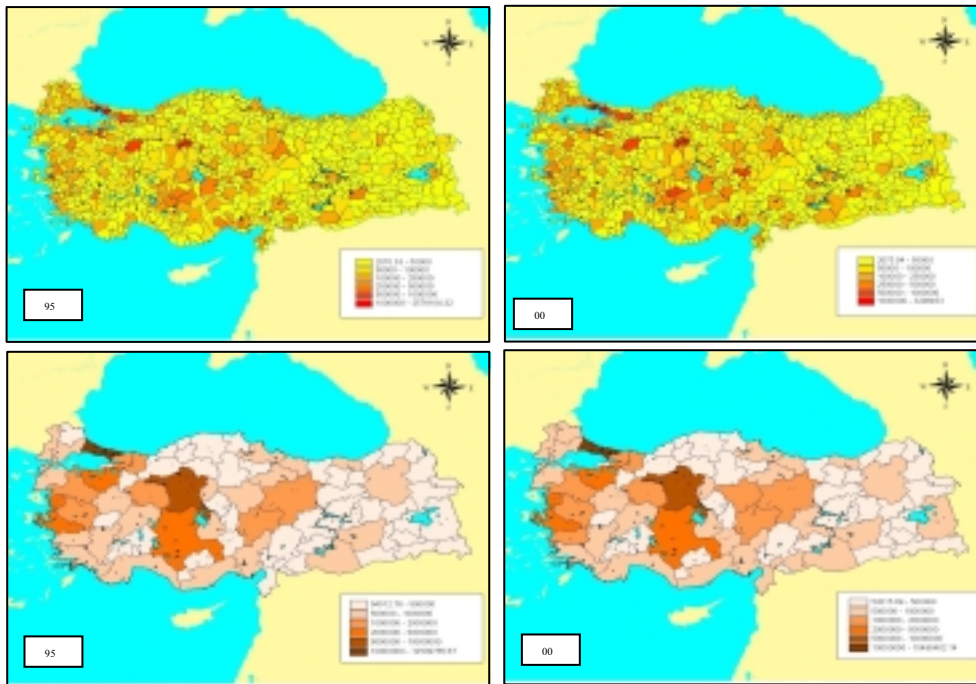


Figure 5. The districts' and provincial CO₂ emission from the households.

The maximum annual industrial CO₂ emission, in 1995, was observed in İskenderun district of Hatay province and Eğrelî district of Zonguldak province with 5.9 and 5.2 million ton/year, respectively. This was also observed at the same places (İskenderun and Eğrelî districts) with respective values of 6.8 and 4.7 million ton/year in 2000. İzmir showed the maximum industrial CO₂ emission (10.1 million ton/year) in both year (Figure 6.).

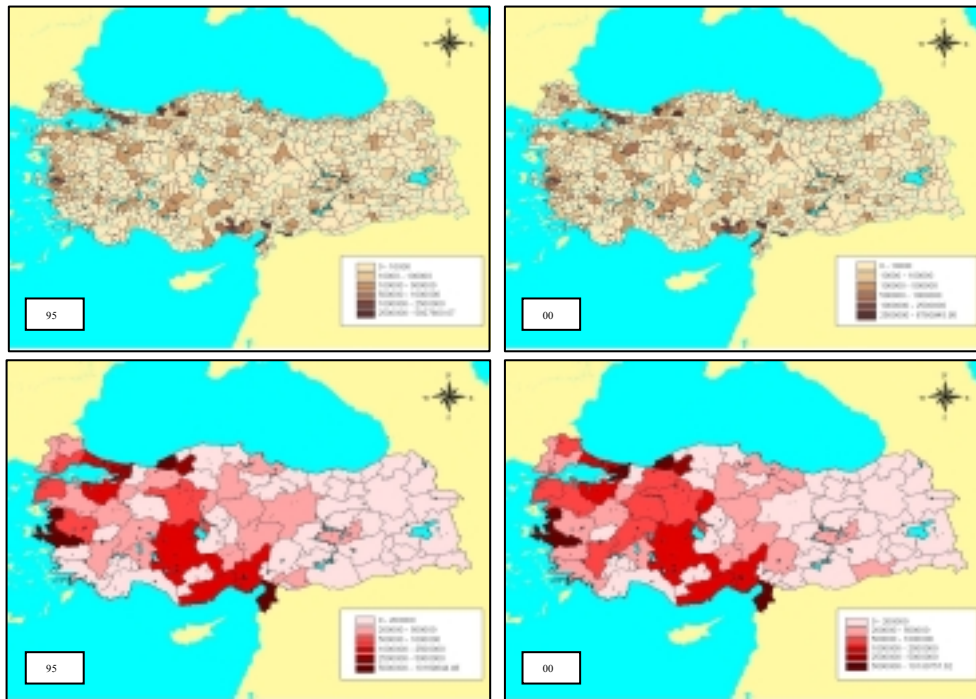


Figure 6. The districts' and provincial CO₂ emission from the Manufacturing Industries.

In 1995, Afsin-Elbistan Power Plant in K.Maraş province emitted 6.2 million ton/year, which was the highest emission rate amongst the power plants. However, Soma Power Plant in

Muğla province took the place of Afsin-Elbistan Power Plant in 2000 and emitted the highest emission with the value of 6.3 million ton/year (Figure 7.).

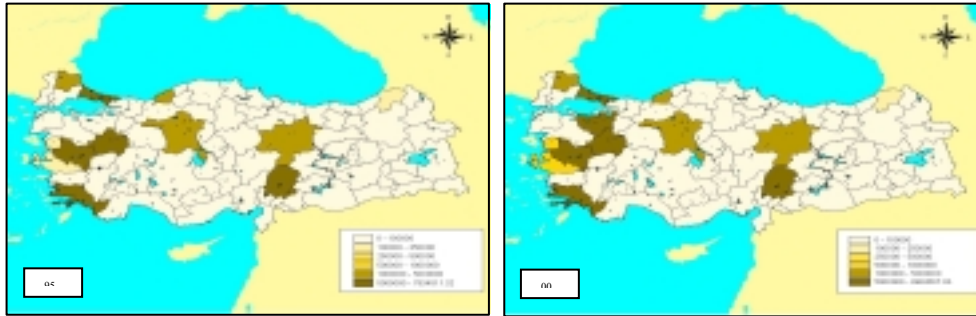


Figure 7. The districts' and provincial CO₂ emission from the Manufacturing Industries.

The result of the road vehicles study shows that for the year of 1995, the maximum CO₂ emission occurred in Bakırköy. The emission was around 1.1 million ton/year. The highest CO₂ emission district and rate of Road vehicles was not altered for the year of 2000 (Figure 8.).

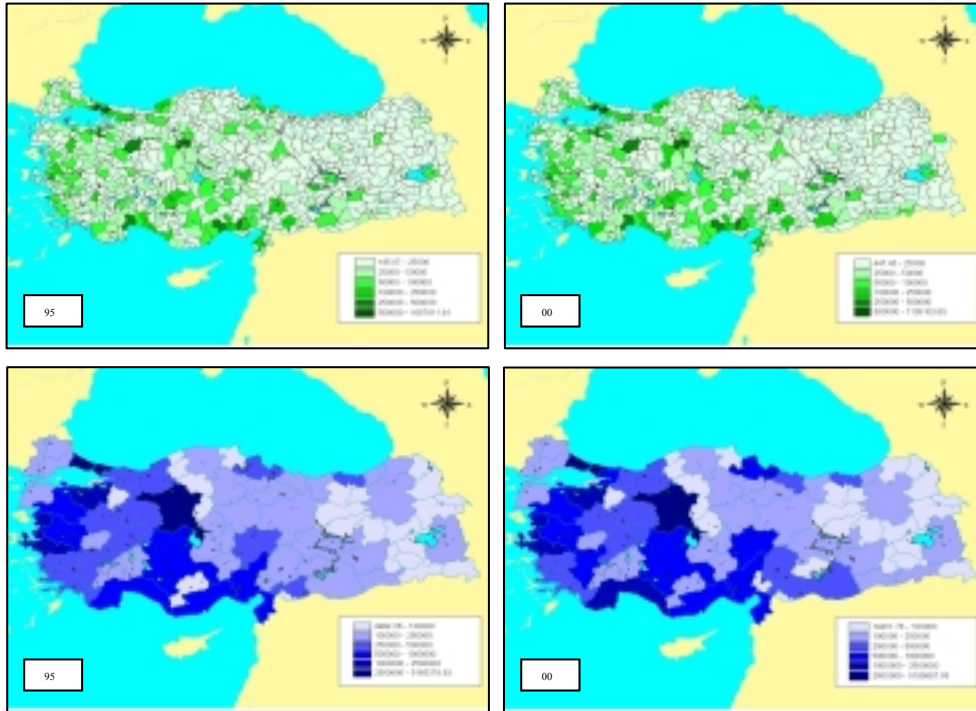


Figure 8. The districts' and provincial CO₂ emission from the Road Vehicles.

CONCLUSION

This study has shown that there are regional, provincial and local changes in CO₂ emission through years. In 1995 and 2000, the maximum CO₂ emissions were from the Marmara Region (around 51 million ton/year) and Aegean Region (around 44 million ton/year). The maximum households' emission was observed in Bakırköy and Kartal districts of İstanbul province with 2.6 and 1.3 million ton/year in 1995 and with 3.3 and 1.6 million ton/year in 2000. The maximum annual industrial CO₂ emission, in 1995, was observed in İskenderun district of Hatay province and Eğrelî district of Zonguldak province with 5.9 and 5.2 million ton/year, respectively. Afsin-Elbistan Power Plant in K.Maraş province emitted 6.2 million

ton/year, which was the highest emission rate amongst the power plants. However, Soma Power Plant in Muğla province took the place of Afsin-Elbistan Power Plant in 2000 and emitted the highest emission with the value of 6.3 million ton/year. The result of the road vehicles study shows that for the year of 1995 and 2000, the maximum CO₂ emission occurred in Bakırköy. The emission in each year was around 1.1 million ton/year. As a result, around 200 million ton CO₂ emitted annually over Turkey. Some cautions have to be taken by the authorities in order to decrease CO₂ emission as is in Kyoto Protocol.

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