INVESTIGATION OF CO_2 UPTAKE OF FORESTS IN TURKEY WITH GIS

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ABSTRACT

Carbon dioxide is mainly formed from combustion of fossil fuels for the generation of energy. Together with CO_2 many other pollutants may be generated. However, CO_2 cannot be removed like other pollutants and it causes greenhouse (GH) effect and ultimately climate change. Reducing the CO_2 emissions and/or increasing the CO_2 uptake is very important because of the environmental concerns and regulations, especially the Kyoto Protocol.

Forests are known to be a good CO_2 sink for the removal of CO_2. In this study, CO_2 uptake capacity of forests in Turkey has been investigated by using Geographic Information System (GIS) techniques. All the 910 districts in Turkey have been considered. The necessary forest data were obtained from the inventories of the Ministry of Forestry. Scaled forest maps were prepared by using GIS programs in the paper by taking three different kinds of forests into consideration. The CO_2 uptake inventory was prepared first by taking the total increments of the forest, then this inventory was linked to the GIS mapping of the forested area and finally the problem was solved. The uptake of CO_2 was calculated by using the FAO method.

The result of this study shows that, there is no forest area in the districts of Ağrı, Iğdır and Nevşehir provinces. The maximum CO_2 uptake is in the Demirköy district of Kırklareli province, Dursunbey of Balıkesir, Çan of Çanakkale with 1159, 964 and 900 thousand tons/year, respectively. The absolute necessity of forestation in the Central and East Anatolia is also an important result of this study.

Key Words: GIS Techniques, Forest Inventory, CO_2 Uptake by forests.

INTRODUCTION

Mankind's impact on the earth's climate should not be underestimated. By using different climate model calculation, scientists have stated that the earth's climate is unstable and the human played an important role on this change [11]. The magnitude and timing of climate change due to all types of activities (natural and man-made activities) will depend on the ultimate concentration of greenhouse gases, their rates of growth and on the detailed response of the climate system [3]. The concentration of greenhouse gases, especially CO_2, has risen considerably after the industrial revolution [1]. Gases are emitted into the atmosphere with an increasing quantity by years due to the combustion of fossil fuels and by the destruction of forests [4]. Destruction of forests (deforestation) is dramatically contributing to the CO_2 emission owing to the 45 percent carbon content of wood [12]. On the other hand, the growth of existing forests may be a significant carbon sink, because an extensive amount of carbon is

absorbed through the increment of biomass (photosynthetic respiration). This means the forests contribute the global carbon budget and climate regulation [4].

The purpose of this study is to investigate the CO_2 uptake capacity of forests in Turkey by using Geographic Information System (GIS) techniques [6; 7; 13]. GIS is an integrated set of procedures for the input, storage, manipulation and output of information relating to specific locations [8; 14; 15]. All 910 districts in Turkey have been considered in this study. The necessary forest data were obtained from the inventories of the Ministry of Forestry. In this study scaled forest maps were prepared by using GIS software and by taking three different kinds of forests into consideration. The inventory was linked to the GIS mapping of forested area. The uptake of CO2 was calculated by using the FAO [2] method.

METHODOLOGY AND ANALYSIS

The forest inventories are present in many countries. A regular inventory has been done for each 5 or 10 year period. The inventory contains the calculation of increment of forest with respect to its type, the composition, the volume, the increment of biomass etc., [2]. In Turkey, such an inventory was not available until 1980s. After 1980, an inventory study has been started and it was finished in 1999 [10]. In this study, FAO method was used to calculate the carbon uptake. The following box summarizes how CO_2 uptake calculation is done.

Biomass = Increment * Dry Density
Total Biomass (Including Roots) = Biomass * (1 + (Root Factor))
Carbon Storage = Total Biomass * 0.45 ton C /ton dry biomass
$C0_2$ Uptake = Carbon Storage * 44 / 12

In this paper, by using GIS programs 1/1000000-scaled forest maps were prepared and three different kinds of forest were taken into consideration. The result is presented in Figure 1.

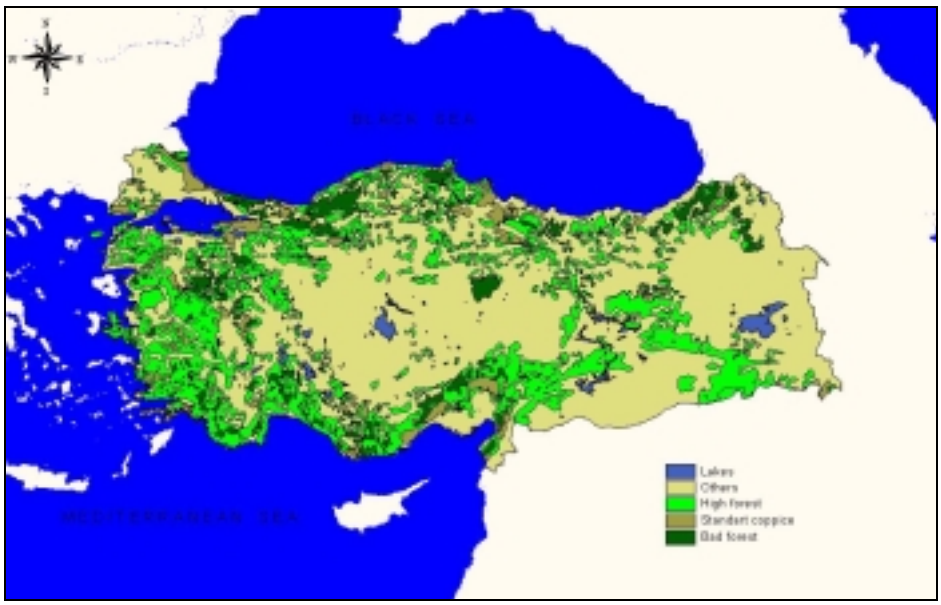

Figure 1. The Forest, Lakes and other land cover of Turkey.

The next step was the calculation of the area of the sinks for each district of the provinces (Figure 2). For this purpose, the maps (layers) were first intersected by using GIS program

and then the area of land cover was obtained for each district of provinces. The results are presented in Table 1.

Figure 2. The districts of Turkey.

Table 1. The area of the land covers for the districts of Ankara provinces.

DISTRICTS	Others	Bad Forest	Standard Coppice	Good Forest	Lake
AKYURT	212.16	-	-	-	-
ALTINDAG	166.97	-	-	-	7.56
GOLBASI	734.75	-	-	-	3.55
AYAS	1108.08	-	-	-	3.66
BALA	2350.84	179.13	-	-	33.17
BEYPAZARI	1255.82	303.57	239.99	-	14.90
CAMLIDERE	168.29	351.73	35.68	-	76.21
CANKAYA	267.61	-	-	-	-
CUBUK	1186.82	163.63	-	-	11.18
ELMADAG	561.17	6.69	-	-	-
ETIMESGUT	49.19	-	-	-	-
EVREN	145.31	-	-	-	34.43
GUDUL	248.86	134.52	0.34	-	-
HAYMANA	2983.56	-	-	-	-
KALECIK	1340.46	-	-	-	-
KAZAN	384.99	23.00	-	-	-
KECIOREN	189.88	-	-	-	-
KIZILCAHAMAM	871.93	873.06	-	-	16.59
MAMAK	470.85	-	-	-	7.55
NALLIHAN	911.27	966.00	-	-	95.28
POLATLI	3458.06	7.68	-	-	-
SEREFLIKOCHISAR	1550.69	-	-	-	577.10
SINCAN	344.26	-	-	-	-
YENIMAHALLE	274.16	-	-	-	-
Total	**21235.99**	**3009.00**	**276.00**	**-**	**881.19**

Unit: km^2

- Calculated by Intersection of Districts' map and Land Cover map of Turkey - GIS techniques.
- This table was formed for each province.

Then the CO_2 uptake inventory was linked to the above tables for each province to obtain the CO_2 uptake of each district.

RESULT AND DISCUSSION

The result of this study shows that forest area is not broad enough in Central Anatolia, Eastern Anatolia and South-Eastern Anatolia regions (see Figure 3 and Table 2). In this study, the forests are classified into three different kinds: Bad forest area, standard coppice area and high forest area. The bad forest and standard coppice areas spread in the Mediterranean, Aegean and Marmara regions. On the other hand, high forest areas are present densely in the Mediterranean and Blacksea regions. In the Blacksea region, Zonguldak and Bolu provinces are important high forest areas. If we look at the districts, Devrek district of Zonguldak province, Dursunbey (Balıkesir), Özvatan (Kayseri), Aladağ (Adana), Uzundere (Erzurum) and Ardanuç (Artvin) are important high forest areas. However, there are not high forest areas in the South-Eastern Anatolia region.

Table 2. Distribution of the forest area within geographical regions

Region	Bad Forest km^2	Standard Coppice km^2	High Forest km^2	Lake km^2	Other km^2	CO2 Uptake Ton
Mediterranean Region	38832	7740	8946	1292	32480	6032570
Eastern Anatolia Region	20167	1965	2393	1878	119927	1900288
Aegean Region	44389	4808	4765	861	34696	5701625
South-Eastern Region	24927	271	0	1316	48995	1086334
Central Anatolia Region	23452	1754	4209	3630	156149	2883835
Black Sea Region	32208	7640	15647	479	59124	16102590
Marmara Region	22680	8539	5988	1323	44064	12091160
Total	**206653**	**32717**	**41948**	**10780**	**495434**	**45798402**

According to the analysis, the percentages for the three different kinds of forests (bad forest, standard coppice and high forest) are 73.46%, 11.63% and 14.91%, respectively. It is also observed that 37.30% of high forest is in the Black Sea Region and 21.33% in the Mediterranean region. The regional distributions of forest are given in Table 2.

All these analysis were carried out by using GIS programs and techniques. During the analysis, 1/1000000-scaled maps [9] were used. The projection of the maps was Lambert Conformal Conic [5].

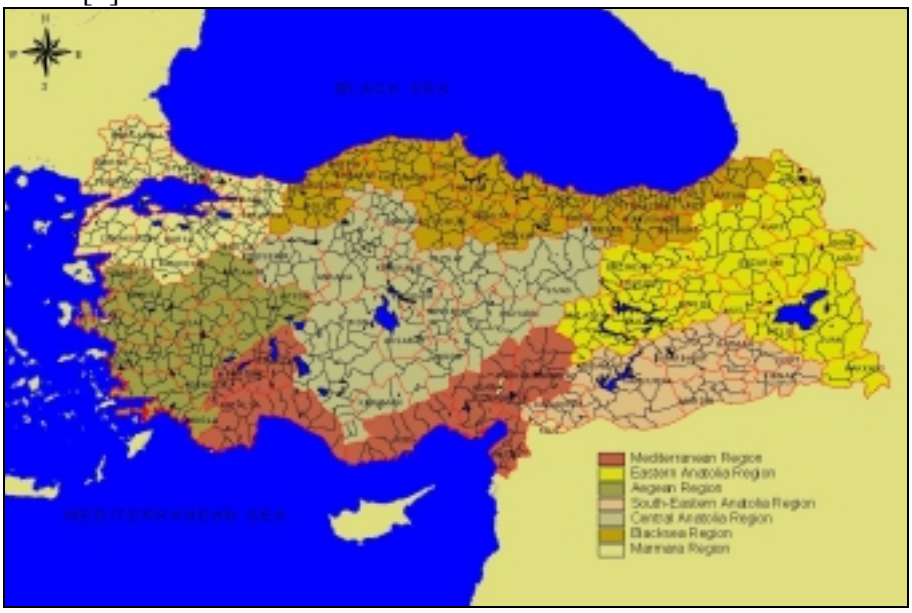

Figure 3. The regions of Turkey.

CO_2 Uptake in Turkey: In order to calculate the CO_2 uptake for the districts, one needs the total increment of forest biomass of the districts. After obtaining the districts' data by using

GIS programs and techniques, the CO_2 uptake in the districts are calculated. The results show that the CO_2 uptake in the coastal zone is higher than that in inland zone as seen in the Figure 4. The CO_2 uptake in the Central Anatolia, Eastern Anatolia and South-Eastern Anatolia regions are 2.88, 1.90 and 1.09 million tons/year, respectively. The maximum CO_2 uptake is in the Black Sea region with a value of 16.10 million tons/year. The Marmara region has the second biggest CO_2 uptake value which is 12.09 million tons/year. It is also observed that CO_2 uptake in the Aegean and Mediterranean regions are 5.70 and 6.03 million tons/year, respectively (see Table 2). The maximum CO_2 uptake values observed in the Demirköy district of Kırklareli province, Dursunbey of Balıkesir, Can of Çanakkale are 1.16, 0.96 and 0.90 million tons/year. There is no CO_2 uptake in the districts of Ağrı, Igdır and Nevşehir provinces. Moreover, there is also no CO_2 uptake in 14 districts of Ankara, 12 districts of Istanbul, 11 districts of Kayseri and 10 districts of Konya as seen in Figure 4. Finally, the CO_2 uptake is present in the 741 districts out of 910 districts considered.

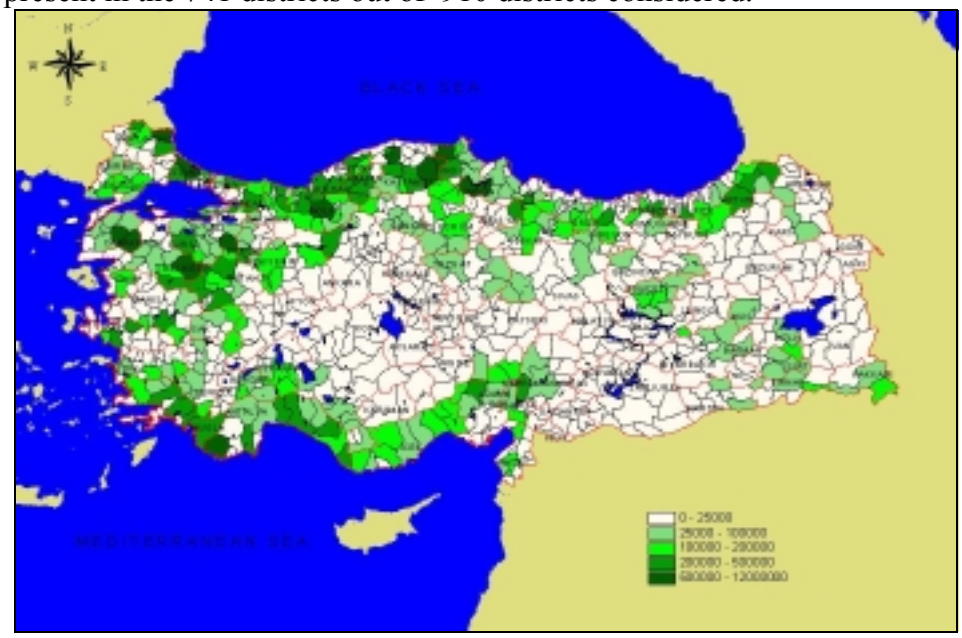

Figure 4. The CO2 uptake of the districts.

CONCLUSION

This study has shown that there are regional changes in the forest area and CO_2 uptake of the forest. High forest areas are present densely in the Mediterranean and Black Sea regions. Moreover, the maximum CO_2 uptake is in the Blacksea region, but not in the Mediterranean region. There is no forest area and hence no CO_2 uptake in the districts of Ağrı, Iğdır and Nevşehir provinces. The maximum CO_2 uptake values in the Demirköy district of Kırklareli province, Dursunbey of Balıkesir, Can of Çanakkale are 1.26, 0.96 and 0.90 million tons/year, respectively. The absolute necessity of forestation in Central and East Anatolia is an important result of this study.

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