A Study to Determine the Relations Between Living Standards and Carbon Footprint Among Geomatics Engineers in Turkey

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Key words: geographic information systems, carbon footprint, thematic map, Turkey

SUMMARY

The main objective of the study is determination of carbon footprint which is very important for use and protection of fresh air and take precautions against the possible increase of these values.

This study contains the results of "Living Standards Survey" which has a total of 38 questions. The participants are members of Chamber of Survey and Cadastre Engineers which has over 10000 members and attached to Union of Chambers of Turkish Engineers and Architects, one of the most important non-governmental organizations of Turkey. The participants are informed via e-mail.

In this study; determining the carbon footprint values among Geomatics engineers in Turkey, analyzing the distribution of values according to information like age, city of residence and income level and visualization via geographic information system were carried out.

Among the questions, besides personal information questions like birth year, city of residence, gender, school that graduated from and graduation year, questions like heating method choices, amount of bills, transportation frequency and transportation preferences are served as the basis of this study.

According to the calculations, Mus has the highest average among cities with 20.86 tones CO_2/year. Bitlis follows with 19.68 tones CO_2/year and Batman with 18.82 tones CO_2/year. For the lowest values, Kars has the lowest with 9.81 tones CO_2/year. Tunceli follows with 11.40 tones CO_2/year and Kırsehir with 11.52 tones CO_2/year. Ardahan, Bartin, Bayburt, Elazıg, Erzincan, Erzurum, Hakkari, Karabuk, Kirikkale, Kilis, Nevsehir, Siirt and Yalova's values couldn't calculate because of no data from this areas. Between geographical regions of Turkey, Blacksea Region has the lowest average with 14.63 CO_2/year and Mediterranean Region has the highest with 15.73 CO_2/year.

Among the European regions, Eastern Europe has the lowest average with 6.80 tones CO_2/year per capita and Western Europe has the highest with 15.00 tones CO_2/year per capita. Among the European countries, average carbon footprint value calculated as 9.8 tones CO_2/year per capita. Albania has the lowest average with 1.8 tones CO_2/year per capita, followed by Armenia with 2.1 tones CO_2/year per capita. On the other hand, Luxembourg has the highest average with 24.6 tones CO_2/year per capita and Belgium is second with 22.2 tones CO_2/year per capita. About place of Turkey, among the 37 countries that has data, Turkey has the 5th highest average value with 15.3 tones CO_2/year per capita.

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1. INTRODUCTION

One of the most important problems of our time is sustainability. Today, the protection of natural resources and ensuring the sustainable management is a major problem. Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). A concept that came up with sustainable living has been the ecological footprint. People consume resources and produce waste until the end of their lives. Productive land and water area that needed for the production of consumed resources and absorb the generated waste is referred as the ecological footprint (Schaller, 1999). In other words, the ecological footprint is the impact of human activities measured in terms of the area of biologically productive land and water required to produce the goods consumed and to assimilate the wastes generated. More simply, it is the amount of the environment necessary to produce the goods and services necessary to support a particular lifestyle.
Ecological footprint is a measure of consumption of natural resources (Hoekstra, 2008). Carbon footprint (CFP) of the frame ecological footprint, measured in units of carbon dioxide (CO_2), is the damage to the environment in terms of the amount of greenhouse gases generated. From this perspective the footprint is a concept that should be known in the context of environmental, social and economic dimensions.
At the beginning of the problems arising with sustainability issues it comes to climate change and global warming. As two of the largest global challenges we face, the global warming and climate change, they present themselves as a natural process and require urgent measures along with the search for solutions. Therefore, various approaches to prevent the accumulation of greenhouse gases in the atmosphere has been developed. Among the gases that have greenhouse effect, it comes to CO_2 as one of the most effectives of all. CO_2, such as a greenhouse or window of a car, lets the sun rays in but does not give out the heat. Because CO_2 has the highest rate among the greenhouse gases that released by human activities, studies have focused primarily on CO_2 analysis.
Reducing the emissions of greenhouse gases (GHG) will coincidentally lead to a reduction of other air pollutants such as fine particles, sulfur dioxide or nitrogen oxides, which cause major problems for air quality. This is because processes by which these pollutants are emitted are the same as those that produce CO_2. They are based on the burning of fossil fuels; so a car engine emits both CO_2 as well as hazardous air pollutants. As the GHG and air pollutant emissions levels decline, the ambient air becomes healthier and the incidence of respiratory and cardiac disease falls.

2. CARBON FOOTPRINT

CFP is the total amount of CO_2 and other greenhouse gases emitted over the full life cycle of a product or process, from extraction of raw materials through to decommissioning. CFP concept is a definition originated within the framework of the ecological footprint. But, there is no consensus on a standard definition of CFP. Whereas, a description as follows can be used; "A 'carbon footprint' is the total amount of CO_2 and other greenhouse gases, emitted over the full life cycle of a process or product." (UK POST, 2006).
At the same time, there is no consensus on how to measure or quantify a carbon footprint. Questions that need to be asked are: Should the carbon footprint include just carbon dioxide (CO_2) emissions or other greenhouse gas emissions as well, e.g. methane? Should it be restricted to carbon-based gases or can it include substances that don't have carbon in their molecule, e.g. N_2O, another powerful greenhouse gas?
Weidmann and Minx (2008) mentioned that instead of all the greenhouse gases CFP should be composed of only CO_2, both direct and indirect effects should be taken into account and the results should be in weight unit (kg, tones etc.).

CFP basically consists two main parts;

1. Primary Carbon Footprint: The sum of the direct carbon dioxide emissions of burning of fossil fuels, like domestic energy consumption by furnaces and waters heaters, and transportation, like automobiles and airplane travel.

2. Secondary Carbon Footprint: The sum of indirect emissions associated with the manufacture and breakdown of all products, services and food an individual or business consumes.

3. METHODOLOGY AND USED DATA

3.1 Study Area and Participants

This study contains the results of "Living Standards Survey" which has 38 questions. The survey created with Google Drive and the participants are members of the Chamber of Survey and Cadastre Engineers. Participants were selected from the members of the Chamber of Survey and Cadastre Engineers in order to have received similar education and formation of similar engineering.
645 responses from 68 cities of Turkey and abroad received from approximately 13000 members of the chamber. Demographic structure determined by directing fundamental questions like birth year, city of residence, gender, alma mater and graduation year. In order to determine CFP, questions in four main topics, especially about heating method choices, amount of bills, transportation frequency and transportation preferences, were prepared and the answers worked as the basis of the study.

3.2 Calculating Carbon Footprint

Questions of the survey were prepared by examining available CFP calculators' surveys and literature studies. To find the answer of the question "How many people do I need to reply survey?" sampling method was applied. For this study, the required number of participants were calculated approximately 390 with an acceptable margin of error of 5%. The number of total return, which is 645 more than necessary. With this return number, 3.8% margin of error was obtained. Then, these CFP values grouped using the information of the participants and found some average values inquires.
There are many web sites can be used to calculate CFP values. In this study, WWF's (World Wide Fund for Nature) calculator was used (URL-1). According to the answers of survey, CFP values calculated for all participants. Using data from living standards survey, CFP values of cities and geographic regions of Turkey calculated with WWF's calculator.

3.3 Analysis of the Value

Assessments were carried out on the basis of people, region, cities and age considering the calculated CFP values. Among geographical regions of Turkey, Black Sea Region has the lowest value with 14.63 tones CO_2/year and Mediterranean Region has the highest with 15.73 tones CO_2/year as shown in Table 1.

Table 1. Average CFP and Participant Values of Geographic Regions of Turkey

Regions	CFP Value (tones CO_2)	Total Members	Participating Members	Participation Percentage
Blacksea	14.63	1524	64	4.20%
Central Anatolia	14.71	3272	136	4.16%
Aegean	14.77	1529	63	4.12%
Eastern Anatolia	14.94	494	18	3.64%
Southeastern Anatolia	14.97	547	18	3.29%
Mediterranean	15.73	1356	57	4.20%
Marmara	15.80	4358	194	4.45%

As the results of calculation, Mus has the highest average carbon footprint value among all the cities of Turkey with 20.86 tones CO2/year per capita and Kars has the lowest value with 9.81 tones CO2/year per capita (Table 2). Calculations could not be made for Ardahan, Bartin, Bayburt, Elazıg, Erzincan, Erzurum, Hakkari, Karabuk, Kirikkale, Kilis, Nevsehir, Siirt and Yalova because there weren't any participants from these cities.

Table 2. Total Chamber Members, Participating Members and Percentages by Provinces

City	CFP Value	Total Chamber Members	Participating Members	Percentage of Participation
Adana	17.80	252	9	4%
Adiyaman	13.39	36	2	6%
Afyon	17.00	76	6	8%
Agrı	11.70	26	1	4%
Aksaray	14.52	52	4	8%
Amasya	15.16	37	2	5%
Ankara	15.89	2076	109	5%
Antalya	16.04	467	18	4%
Ardahan	0.00	9	0	0%
Artvin	17.65	40	3	8%
Aydin	15.77	160	8	5%
Balikesir	17.05	111	2	2%
Bartin	0.00	16	0	0%
Batman	18.82	59	2	3%
Bayburt	0.00	6	0	0%
Bilecik	14.18	30	1	3%
Bingol	14.45	7	2	29%
Bitlis	19.68	27	2	7%
Bolu	12.29	56	1	2%
Burdur	16.16	27	2	7%
Bursa	16.43	390	26	7%
Canakkale	15.88	83	7	8%
Cankiri	17.50	28	2	7%
Corum	14.53	73	3	4%
Denizli	16.19	148	4	3%
Diyarbakir	16.68	131	4	3%
Duzce	18.77	42	3	7%
Edirne	13.95	50	2	4%
Elazıg	0.00	72	0	0%
Erzincan	0.00	36	0	0%
Erzurum	0.00	50	0	0%
Eskisehir	16.64	122	3	2%
Gaziantep	16.61	126	7	6%
Giresun	13.37	67	4	6%
Gümüshane	17.22	30	4	13%

Hakkari	0.00	16	0	0%
Hatay	14.02	147	9	6%
Igdır	16.43	15	2	13%
Isparta	15.42	51	3	6%
Istanbul	16.69	3157	151	5%
Izmir	14.33	636	32	5%
Kahramanmaras	15.87	127	6	5%
Karabük	0.00	35	0	0%
Karaman	12.70	33	1	3%
Kars	9.81	14	1	7%
Kastamonu	16.81	50	2	4%
Kayseri	14.58	189	6	3%
Kirikkale	0.00	42	0	0%
Kırklareli	14.49	39	4	10%
Kırsehir	11.52	36	1	3%
Kilis	0.00	5	0	0%
Kocaeli	16.69	226	13	6%
Konya	14.74	514	23	4%
Kutahya	14.06	78	2	3%
Malatya	16.09	86	5	6%
Manisa	14.90	119	7	6%
Mardin	13.35	49	1	2%
Mersin	13.30	240	12	5%
Mugla	13.23	269	13	5%
Mus	20.86	19	1	5%
Nevsehir	0.00	32	0	0%
Nigde	13.51	51	2	4%
Ordu	13.66	87	5	6%
Osmaniye	17.19	45	7	16%
Rize	13.37	42	5	12%
Sakarya	17.82	106	5	5%
Samsun	13.39	294	12	4%
Siirt	0.00	23	0	0%
Sinop	12.51	35	4	11%
Sivas	13.62	72	5	7%
Sanlıurfa	11.85	100	7	7%
Sirnak	14.07	18	2	11%
Tekirdag	14.80	121	5	4%
Tokat	13.73	64	3	5%
Trabzon	13.30	443	16	4%
Tunceli	11.40	15	1	7%
Usak	12.64	43	3	7%

Van	14.07	102	8	8%
Yalova	0.00	45	0	0%
Yozgat	16.58	24	2	8%
Zonguldak	13.73	107	5	5%

3.4 GIS-Based Maps

Fist process to begin creating CFP maps is calculate values on the basis of provinces and import them to the system. The average value of all individuals in a province gives the average value of that city. After calculate and transfer the CFP values of the cities, next step is perform a similar process for the geographical regions (Mediterranean Region, Black Sea region, Aegean Region, Marmara Region, Central Anatolia Region, Eastern Anatolia Region and Southeastern Anatolia Region). After all necessary data imported to the system, next step is creating the maps.

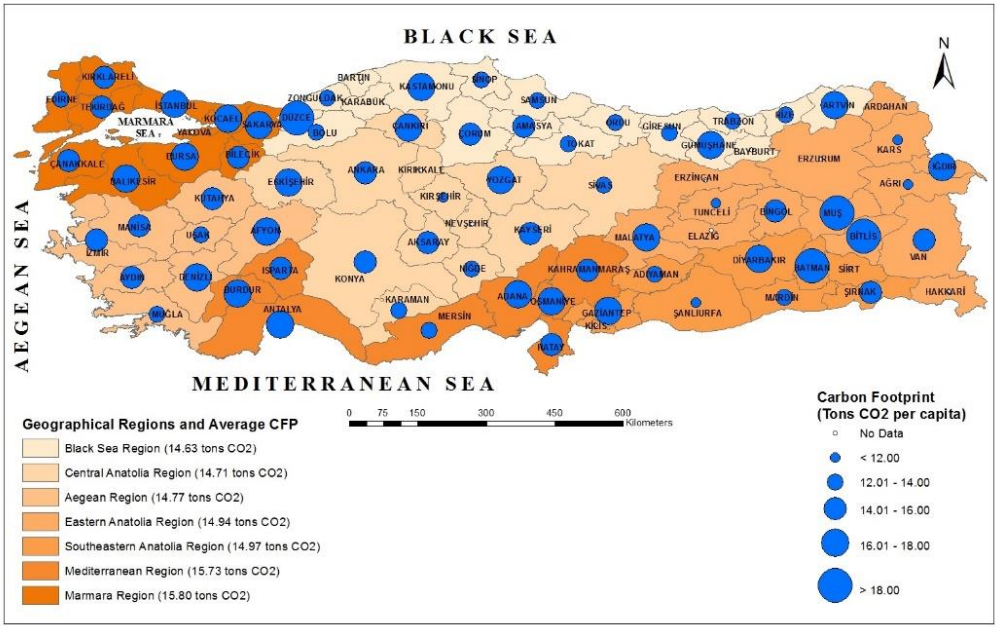

Figure 1. CFP Map of Turkey by Provinces and Geographic Regions

To produce CFP map of Europe, Similar steps were applied. The first step was to obtain the countries CFP values. For Turkey, an average value was found using the previously calculated CFP values of Geomatics engineers that living in the country. For European countries, 2010 data provided by the Carbon Footprints of Nations organization was used. In the next step, Europe is divided into four geographical regions as Eastern Europe, Southern Europe, Northern Europe and Western Europe.

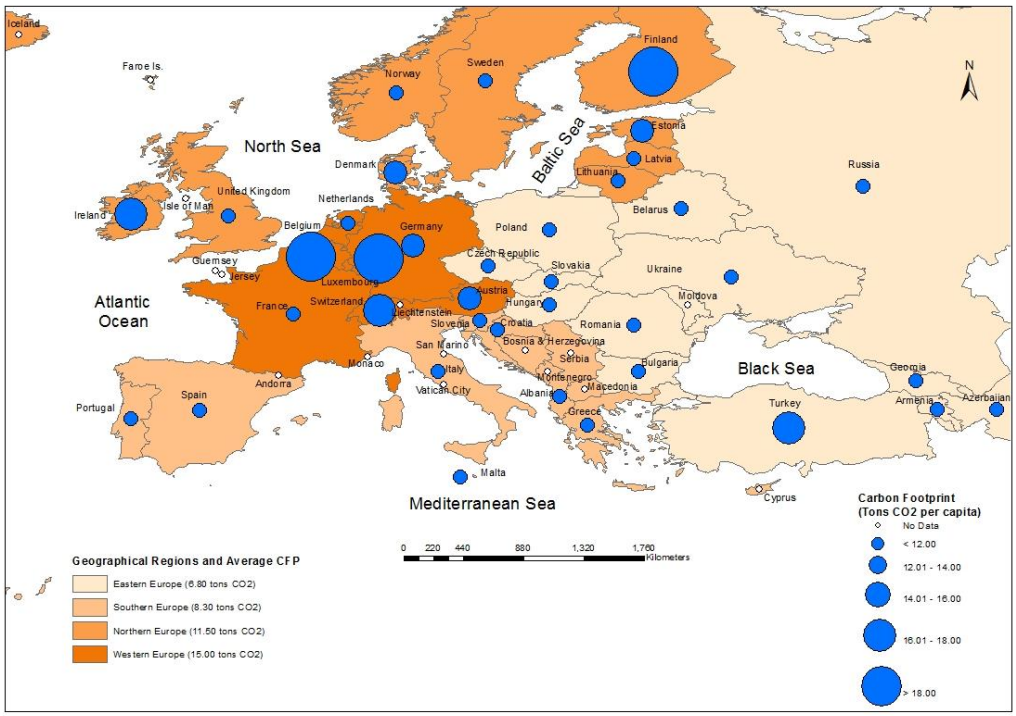

Figure 2. CFP Map of Turkey and Other European Countries

4. RESULTS AND SUGGESTIONS

When Geomatics Engineers in Turkey grouped depending on their income distribution, 6% has low income (0-450 €/month), %20 has medium income (450-850 €/month), %42 has high income (850-1200 €/month) and %33 has very high income (more than 1200 €/month). When evaluating CFP values compared to income, it's seen that very high income group has the highest values with 16.71 tones CO_2/year.

According to the distribution by gender; 87% of the participants are male and 13% of them are female. Average CFP for male Geomatics engineers is 15.34 tones CO_2/year and average for female Geomatics engineers is 15.29 tones CO_2/year.

Considering the age groups, 40 and above group (32% of the participants) has the highest value with 16.25 tones CO_2/year. 30-40 group (35% of the participants) follows with 15.47 tones CO_2/year and 20-30 group (33% of the participants) with 14.25 tones CO_2/year. Although the 20-30 age group doesn't have a high income, because of their active life they use transportation intensely. Notwithstanding, personal care consumptions come with modern life are direct reasons of CFP increase. When we look at the 30-40 age group, they often use airlines because of their active business life. This has a significant effect on CFP. Also, this age group spent more money than the others on technological equipment like cellphones, computers etc. For above 40 age group, there is an increase in the domestic heating and other daily activities. In these ages, due to spend more time at home, indoor activities have more effect on CFP values.

According the results of the evaluation among the provinces, average CFP value for Turkey was found as 15.34 tones CO_2/year. The lowest value among the cities is 9.81 tones CO_2/year for Kars and the highest values is 20.86 tones CO_2/year for Mus. Among the geographical regions of Turkey, Black Sea Region has the lowest overall of CFP with 14.63 tones CO_2/year and Mediterranean Region has the highest overall with 15.73 tones CO_2/year. About the reasons of high CFP values, it could be said that for western parts, fossil fuel usage for transportation and industry and for the eastern parts fuel used for heating are the major factors.
Among the European regions, Eastern Europe has the lowest average with 6.80 tones CO2/year per capita and Western Europe has the highest with 15.00 tones CO2/year per capita. Among the European countries, average carbon footprint value calculated as 9.8 tones CO2/year per capita. Albania has the lowest average with 1.8 tones CO2/year per capita, followed by Armenia with 2.1 tones CO2/year per capita. On the other hand, Luxembourg has the highest average with 24.6 tones CO2/year per capita and Belgium is second with 22.2 tones CO2/year per capita. About place of Turkey, among the 37 countries that has data, Turkey has the 5th highest average value with 15.3 tones CO2/year per capita. As the main reasons of high CFP in western countries; high income, the abundance of carbon release activities due to the high level of income, high rate of industrialization and therefore excess consumption of fossil fuels can be mentioned.
The value calculated for Turkey belongs to 2014 and it contains only the information of Geomatics engineers. At the same time, values for European countries belong to 2010 and from a different source. Because of that, there is no exact comparison between them. However, these assessments are carried out with an important qualities in terms of providing awareness.
Greenhouse gases that released into the atmosphere as a result of human activities are the main reasons of global warming because of their heat retention capacity. Carbon footprint concept consisting of CO_2, the most important of these greenhouse gases, is an increasingly popular topic mainly due to its rise and effects to the nature. Minimizing the carbon footprint, especially with regard to the prevention of global warming is more important than ever. Developed countries are producing more carbon emissions and lifestyles are becoming also consume more energy. Using renewable green energy sector, which is a more healthy form of energy without affecting global pollution, should be initiated as soon as possible.

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BIOGRAPHICAL NOTES

Batuhan Sariturk; is a PhD student and research/teaching assistant at Istanbul Technical University, Department of Geomatics Engineering. He graduated from Karadeniz Technical University, Department of Geodesy and Photogrammetry Engineering in 2012, obtained his master degree from Istanbul Technical University, Department of Geomatics Engineering in 2014.

Dursun Zafer Şeker; graduated from Istanbul Technical University (ITU), Civil Engineering Faculty, Department of Geodesy and Photogrammetry in 1985, completed his Master degree in 1988 and PhD degree in 1993 in the same department. His researches and studies are mostly related to GIS, photogrammetry and remote sensing. His expertise and current research activities are focused in the area of GIS and remote sensing on the environmental issues, GIS-based watershed management and documentation of cultural heritage. He is also an active member of the Chamber of Surveying Engineers of Turkey. He has been working at the Department of Geomatics of ITU since 1986.

Nuket Sivri; is is an Academic Researcher at Istanbul University since 2004. She obtained her MSc and PhD degrees from the Department of Marine Sciences, Karadeniz Technical University in 1999. Her further post doctorate studies were carried out at the Plymouth Marine Laboratory, UK. Her main interest is the importance of water resources. In this topic, her studies are concerned with the interaction between algae, nutrient dynamics and enteric bacteria, coastal area dynamics. In addition, her research focuses mainly on understanding the role of microorganisms in the coastal area using genomic approaches and the development of novel technologies for promoting microalgal growth.

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