The relationship between income level and CFP level of the provinces in Turkey: a case study

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Abstract: This study determines the distribution of carbon footprint values (CFP) in Turkey by income levels, gender, age group, provinces where people live and the geographical regions of these provinces. In addition, % distribution of human activities which lead to CFP (food, travel, home, stuff) has been analysed. The carbon emission values assessed in this study have been compared with annual carbon emission distributions of various countries. In comparison by income levels, it was observed that mainly consumption-based usages (48%) take part in spending of people in the lowest income section while travel costs (42%) of people having high income have a significant contribution to CFP values. In assessment by age groups, it was observed that the highest CFP value is obtained by those aged 40 or older (in average; 17.1 tons CO_2 per capita). In assessment of CFP values on the basis of geographical region and province, it was seen that high CFP values which result from the fuel type used for heating in eastern regions of Turkey replace CFP values related to transportation in western parts. In Turkey, annual carbon emission value is 15.1 tons CO_2 per capita in average. This value is similar to annual carbon emission per capita of European countries such as Spain, France.

Keywords: carbon footprint; CFP; Turkey; annual CO_2 emission; income level.

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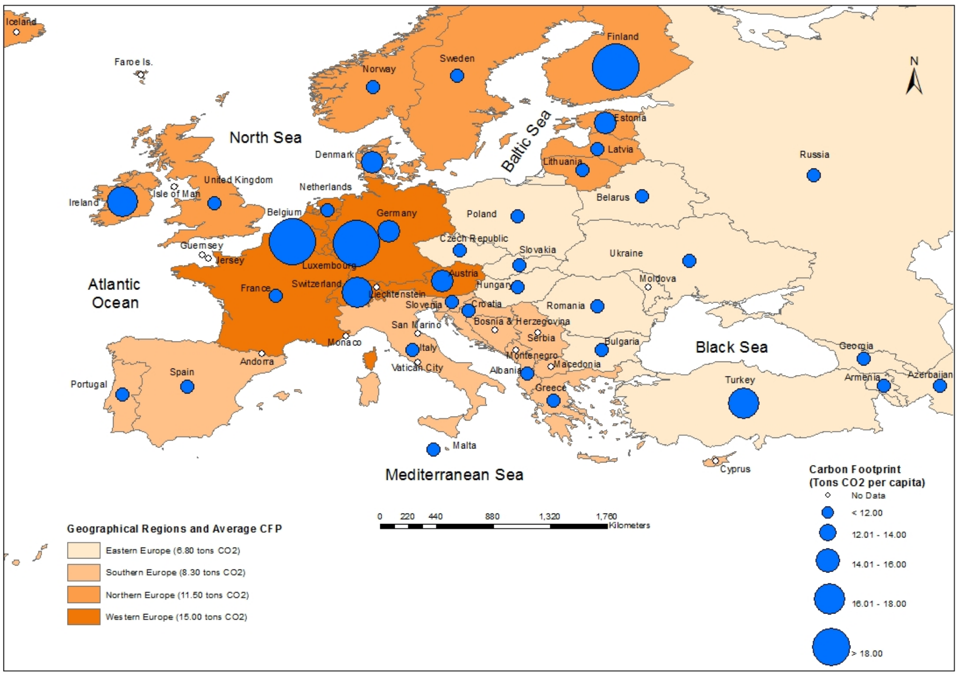
1 Introduction

Today, it is an important problem to protect natural resources and ensure sustainable management. A measure for natural resources consumed by people is defined by the term 'footprint' (Hoekstra, 2008). Sustainable development refers to the development that "meets the needs of the present without compromising the abilities of future generations to meet their own needs" (WCED, 1987), and it requires an integration of not only environmental but also economic and social components at all levels (OECD, 2004; Cucek et al., 2012). In this respect, footprint is an important concept which has environmental, social and economic dimensions and thus should be known in territorial context.

Usage rate of people in using natural resources is faster than the renewal rate of these resources; for this reason 'carbon footprint (CFP)' has recently been one of the most important environmental protection indicators (Lam et al., 2010; Cucek et al., 2012). CFP has been defined as a measure for the emission of carbondioxide (CO_2) and other greenhouse gases (GHGs) which diffuse into atmosphere by the use of fossil fuels and are considered to be the main guilty of global warming (Wiedmann and Minx, 2008). In other words, it refers to the damage of people and companies to the world by energy usage directly or in terms of the consumption of products. CFP consists of two main parts being direct/primary footprint and indirect/secondary footprint. The primary footprint is the measure for direct CO_2 emissions which reveal by fossil fuel burning including domestic energy consumption and transportation (car, plane etc.) while the secondary footprint is the measure of indirect CO_2 emissions related to the manufacturing of the products that we use within the whole life cycle and finally their deterioration. In all those consumptions mentioned, especially aviation sector is directly responsible for approximately 700 million tons of CO_2 emission every year. The condensation trail, which comes out from jet motors at high altitude and can form a cirrus cloud, increases the direct effect of CO_2 about three times (Atabey, 2013). Another important factor is sourced from road vehicles, which is responsible for 75% of all greenhouse gas emission. Public transportation methods, which are encouraged to use in common by local authorities, seems to be carbon-friendly choice in general. Preferred transportation methods are also in close relation with CFP values.

Figure 1 C emissions of different countries and related CFP values (see online version for colours)



Source: Prepared on the basis of the data in Hertwich and Peters (2009) and https://www.eureapa.net/explore/?region_id=41

In recent years, the interest towards CFP has brought along the focus of researchers on this field. In literature, there are many studies on CFP. In their study, Hertwich and Peters (2009) analyses and compares the CFP of different countries using a single, trade-linked model of the global economy. Murray and Dey (2009) tested the selected CFP measuring portals. Shrestha et al. (2011) aimed to detect CFP of sea water purification and convection in water supply to settlement areas being away from drinking water areas, in their study. In the study conducted in 2012, Alderson et al. measured CFP of electricity generation of UK until 2050 through various scenarios. Soni et al. (2013) investigated energy consumption and CO_2 emissions in rain fed agricultural production systems of Northeast Thailand. Their study simultaneously relates energy consumption in agricultural production systems associated with their corresponding GHGs emission – presented in terms of total carbon dioxide equivalent (CO_2e). However, all these studies basically aim to enable different approaches developed by their own country to be adopted in order to reduce CO_2 emissions together with economic growth by force of the strong relationship between global climate change and energy-based CO_2 emissions (Yuan et al., 2011). According to these studies, C emission of different countries and related CFP values are presented in Figure 1.

As can be seen in Figure 1, CO_2 values are high as 11 tons per capita in Western Europe and Northern Europe where industrialisation rates are high. The footprint has increased for all land categories between the years 1961 and 2007, but the highest increase occurred in CFP. This value has shown an increase starting from mid 19^{th} century, specifically from the Industrial Revolution, since when the World started to depend on fossil fuels for economical growth. In addition to fossil fuel usage, this increase can be explained by multiple factors, such as changes in land usage, fast population growth, over urbanisation and deforestation, industrialisation and industrial processes. In existing 3P problem of the world (pollution, population, powerty), increases in life quality and luxury consumption habits and necessities has increased the CFP level. As we head towards Eastern Europe, we can see these values drop. Total consumption footprint (all GHGs) value [390,757 kilo tons (KT)] of Turkey is approximately half of that in England (995,877 KT), France (747,036 KT) and Italy (744,389 KT); one third of that in Germany (1,298,868 KT); 1/20 of the USA (7,825,865 KT). In worldwide concept, Turkey has 390,757 KT and has 1.07% rate within a total of 36,511,204 KT (http://www.eureapa.net). In terms of CO_2 emission, Turkey has 298,002 KT and thus has 0.89% rate in worldwide. In the same list, values of the following countries can be seen as; Thailand 295,282 KT (0.88%), China 8,286,892 KT (24.65%), Arab World 1,601,122 KT (4.76%), Japan 1,170,715 KT (3.48%), USA 5,433,057 KT (16.16%) (World Bank: http://data.worldbank.org/indicator).

In the literature review on CFP of Turkey, age groups and income levels provided a basis and no similar study was found. This research article aims to create a database about CFP in comparison with Turkey and EU countries to fulfil a gap in this topic. In this line, CFP values in Turkey were determined through the distribution of gender, age, educational background and income levels in Turkey geography. Percentage (%) distributions of the factors which result in CFP within each age group were also analysed and then carbon emission values of Turkey were compared with annual carbon emission values in various countries.

2 Material and methods

Survey study was conducted on people in three different age groups (20–30 years, 30–40 years, >40 years) from each province of Turkey and annual carbon emission amounts were calculated. Age, educational background, gender and income levels of people were considered and CFP definitions were used as a base and the questions related to the detection of consumption-oriented habits and determination of carbon emissions were asked. These were determined as follows; food habits, travel preferences, home costs and consumption habits. Especially these groups were selected as the main categories which were emphasised in CFP definitions for calculations.

In this study, the phase layer sampling method was preferred. In the first stage, three age groups were divided as income level sampling units. According to the size of the survey and since the analyses had to be carried out for three different age groups, the optimum participant number n was formulised, considering 0.90 meaning level, 0.05 errors and for the correct guess for the ratio. In the survey, each question has four answers, so each answer has 0.25 ratios to be chosen.

Different tools (GIS and cluster analysis) were used in order to easily follow up the changes in CFP by geographical changes and the provinces; to obtain more comprehensible data and determine the difference between the provinces in Turkey.

The first one of these tools is geographic information system (GIS). GIS is basically defined as a set of software and hardware which can link descriptive and spatial information for the analysis as a set of useful tool thanks to its ability to identify spatial connections between different information layers. With this method, the surfaces created by using inverse distance weighting (IDW) method can be used to visualise, analyse, and understand spatial phenomena. In this geostatistical method, it is substantially assumed that the rate of correlations and similarities between neighbours is proportional to the distance between them and can be defined as a distance reverse function of every point from neighbouring points (Ozman Say et al., 2010; Ly et al., 2011; Sivri et al., 2012; Sarıtürk, 2015). In this study, CFP level distribution of the European area and provinces in Turkey was found using this geostatistical method. Country changes and transitions are statistically much more important and have been presented in Figure 1, details of the provinces in Turkey are presented in Figure 2 in the map form produced by using GIS. The reference circles shown in the respective figures represented as CFP tons per capita was selected so as to make comparison of the values among the countries of Europe and the provinces of Turkey. Geographical areas have been limited with colours and averages of CFP have been taken. To make a visual distinction, geographical areas and provinces have been identified on the maps with CFP levels.

3 Results

In this study, survey results were assessed on the basis of income distribution, gender, age groups, provinces and geographical regions of these provinces.

In classification of income level throughout Turkey by lower, medium and high income groups, it can be seen that out of all household heads, 45.7% are in lower; 39.1% are in medium and 15.2% are in high income group (Turan, 2011). As the results clearly showed in terms of educational background and jobs being among the most important factors which affect income distribution, mainly consumption-based usages (48%) take part in spendings of people taking place in the lowest income segment while travel costs (42%) are important in CFP values of people with high income. The costs of public having normal income, except for the travel item, are almost equivalent.

According to the results obtained by gender, (male: 15.34 tons CO_2 per capita and female: 15.29 tons CO_2 per capita), statistically no significant difference was found in luxury consumption habits in terms of CFP generation for both groups. Taking stand from this information, CFP values determined by income levels of people who took part in survey are presented in Table 1.

Table 1 The change of CFP values of people living in Turkey by income level

	Food%	*Travel %*	*Home costs %*	*Consumption H. %*	*Annual C*
Turkey (mean)	*19*	*21*	*24*	*36*	15.10
Low income	15	10	27	48	13.30
Normal income	27	15	23	35	15.31
High income	12	42	21	25	16.71

According to the analysis on distribution of CFP values considering age groups in the study, the highest CFP value was found in people aged 40 or older (in average; 17.1 tons CO_2 per capita). In the order of CFP mean values, 30–40 age groups has 15.1 tons CO_2 per capita values and 20-30 age group has 13.3 tons CO_2 in average, per capita values. Within the light of the data obtained from the recent population census in Turkey, there are 17,817,766 people aged 40 and older living in the oldest age group which took part in the survey and there are 12,369,818 people in 30-40 age group while there are 12,500,356 people in 20-30 age group (TUIK, 2014). In the calculation based on the mean CFP values of each age group, the total annual CO_2/year value was found to be 657×10^6 tons. In consideration of age groups, Table 2 presents the total annual carbon emission values for each age group through the number of people in these age groups. As the population of the group aged 40 and older is much higher than others (approximately two times more), the annual C emission from this age group was found very high While the total calculated C emission for all these age groups was 657,722,785 tons CO_2/year, C emission related to the activities of people aged 40 and older was calculated as 304,683,799 tons CO_2/year.

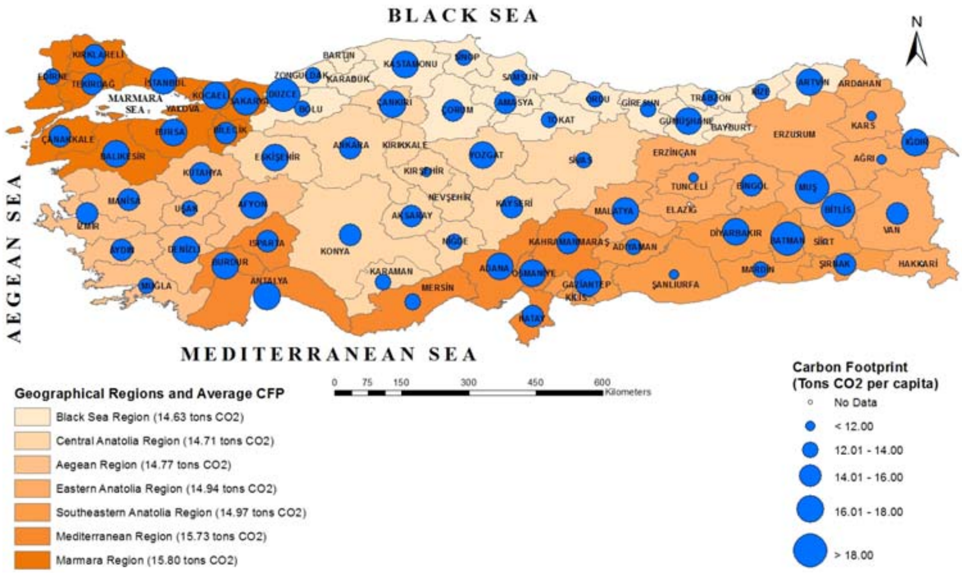
Table 2 Percentage contribution of human activities in determination of CFP values by age groups

Age	*Food (%)*	*Travel(%)*	*Home(%)*	*Stuff(%)*	*Planets*	*C (tons CO_2 per capita)*
Ages 20–30	20	31.8	17.97	30.51	3.06	13.3
Ages 30–40	18.17	29.33	20.33	34	3.14	15.1
Ages >40	23.86	18	23.43	35	2.59	17.1

In the assessment made between regions throughout Turkey, the lowest mean value was found in Black Sea region with 14.63 tons CO_2 per capita which is followed by Central Anatolia with 14.71 tons CO_2 per capita, Aegean with 14.77 tons CO_2 per capita, Eastern Anatolia with 14.94 tons CO_2 per capita, Southeastern Anatolia with 14.97 tons CO_2 per capita, Marmara with 15.70 tons CO_2 per capita and Mediterranean with 15.73 tons CO_2 per capita. These results are presented in Figure 2.

The assessment results on province basis are presented in Figure 2. In the assessment in terms of provinces, it was found that the mean CFP values of 42 provinces in Turkey were 15.36 tons CO_2 per capita. This value is very close to the mean value in Turkey. The lowest CFP values were found in following provinces Kars (10.40 tons CO_2 per capita), Tunceli (10.99 tons CO_2 per capita), Ağrı (10.75 tons CO_2 per capita), respectively. The values of other 18 provinces in Turkey differed between 12 and 14 tons CO_2 per capita. The highest CFP values were found in following provinces Adana (19.12 tons CO_2 per capita), Mardin (18.73tons CO_2 per capita) and Gümüşhane (18.26 tons CO_2 per capita), respectively. These provinces were found as the provinces which affect the mean values of the region where they are located (Sarıtürk, 2015; Sarıtürk et al., 2015).

Figure 2 The change of CFP values by provinces and geographical regions (see online version for colours)



The change of total CFP value of Turkey from 2001 to 2013 is presented in Table 3. It can be seen that the contribution of food-derived CFP to annual total CFP tends to decrease from 2001 to 2013. The contribution of travel and home to the total CFP increased compared to 2001 and 2004 (Table 3). The contribution of Stuff to total CFP had the highest value among all consumption categories. The data in the study of Hertwich and Peters (2009) were used to calculate the data of 2001 while the data at https://www.eureapa.net/explore/?region_id=41 source were used for the data of 2004.

Table 3 Contribution of different consumption categories of CFP in Turkey by years

Year	*Food (%)*	*Travel (%)*	*Home (%)*	*Stuff (%)*
2001	27	24	15	34
2004	24.28	21.75	11.97	42
2013	20.67	26.38	20.58	32.37

4 Discussion and conclusions

Today, CFP is a very popular topic. There is a great tendency towards reducing CFP in terms of the protection and sustainability of environment and ecology. Calculations on the ecological demand of personal, societal and investment spending separately show the contribution of various final personal consumption categories (food, goods, transportation, services and housing) on the Ecological Footprint in Turkey.

As can be seen in Table 1, the contribution of personal travel costs (42%) of the section having high income level to the increase in annual C amount is very high compared to other options. In the group with low income, the spendings made for stuff constitute 48% of CFP. Carbon emissions derived from home costs have almost equal percentage for all income groups. The frequent preference of people with high income level in long-distance flight for domestic and foreign travels and their preference in personal large-type and gasoline-powered vehicles apart from public transportation vehicles such as train and bus lead to high value of CFP. These values can be found higher depending on the type of the used vehicle and the damage of its fuel to the nature.

When participants are grouped by income levels, 6% had 1,500 TRY (approx. 500 €), 20% had between 1,500–2,800 TRY, 42% had between 2800–4000 TRY and 33% had more than 4000 TRY (approx. 1300 €) (Sarıtürk, 2015; Sarıtürk et al., 2015). CFP evaluation by income levels has shown that they have direct correlation. Highest CFP level per person was in high income group with 16.71 tons CO_2/year, followed by 14.80 tons CO_2/year in middle income and 13.30 tons CO_2/year in low income groups. Also, it was thought that CFP values may be affected from travel expenses, which is found mostly in high income group.

In the analysis of human activities which lead to carbon emission in age groups (Table 2), it was found that travel leads to the highest C emission with 31.8% in the 20–30 age group. For this age group, it was followed by stuff (30.51%) (Table 2). The 30–40 age group has a similar tendency like the 20–30 age group (Table 2), however, this age group has a higher CFP value. Spendings on technological tools such as mobile phones, computers are higher in this age group. On the other hand, it was found that travel-derived C emissions of those aged 40 and older are lower compared to other age groups.

Although the 20–30 age group does not have high income level, they have active life characteristics and thus they definitely use a transportation vehicle. In addition, their consumption of personal maintenance products by force of modern life increases their luxury consumption and thus CFP. It was seen that the reason of the high CFP value in 30–40 age group is the fact that this age group prefers transportation due to active business life; especially those in high income level prefer airways for domestic and foreign transportation. The concentration on activities such as travelling which play effective role in carbon emission is a remarkable topic. The increase in domestic heating and other daily expenditures of people aged 40 and older is remarkable as well. In advanced ages, home and stuff activities become more effective due to spending more time at home.

Annual carbon emission value of Turkey per capita is similar to some European countries such as Spain and France. It is believed that the similarity in development level and consumption habits led to this result. As can be seen in Figure 1, annual carbon emission values per capita in developed and underdeveloped countries are very different. The carbon emission value per capita in developed countries like USA, Belgium, Canada is much higher than the values in underdeveloped countries like Bangladesh, Mozambique, Zimbabwe. For example, this value is 28.6 tons CO_2 per capita for USA while it is 1.1 tons CO_2 per capita for Bangladesh. The mean annual carbon emission value in Turkey is 15.1 tons CO_2 per capita.

Consumption habits change due to global-scale, big economic crises (2008, 2011). These habits result from socio-economic imbalances between regions; in broader sense, from the differences in agriculture, commerce, service, industry, communication, transportation, health, education, demographic and social indicators between regions. The results related to all these differences lead to the differentiation in income distribution of regions. For this reason, imbalances in income distribution should not be assessed alone; imbalances derived from the related socio-economic factors should be revealed and the results should be assessed to look for solution ways (Turan, 2011). In this study, clear differences between regions relatively affect income distribution as well. It is remarkable that high CFP values which result from the fuel type used for heating in eastern regions of Turkey replace transportation-derived CFP values in Western regions. In addition, transportation-related high CFP values were detected in provinces where public transportation is not common. Red meat-oriented nutrition in Eastern and Southeaster Region depending on food habits is assessed as an important feature to increase CFP value. In Black Sea and Aegean regions having a nutrition habit based on vegetables and legumes, low use for heating and low luxury consumption compared to other regions make these regions take place in the regions having the lowest mean value. Especially, different geographical characteristics of Black Sea region lead to low transportation-derived CFP values.

To decrease CFP values is especially important to support the prevention of global warming. In order to decrease fossil fuel consumption which leads to increase in CFP value, local administrations should raise awareness of public. The steps that should be taken to use alternative energy sources instead of fossil fuels should be determined by decision makers and great steps should be taken to make this issue among priorities of the country. On other hand, one of the important results that the present study reveals is the fact that an effort should be made to change luxury consumption habits which lead to increase in CFP value. In addition, to regulate daily activity and usage habits has great importance to decrease CFP value. Some methods to prevent high CFP values can be exemplified as finding alternatives to driving or keeping an effective driving style, using a fuel efficient vehicle, sealing home, effective lightning, using thermostats, being a part of recycling/reuse/recovery activities and supporting clean energy sources.

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