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# The Influence of Road Transport on Carbon Footprint: A Case Study of the Black Sea Region

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**Abstract**

Global warming is a critical issue that impacts all countries on earth. Recently, the increase in global warming and the spread of greenhouse gases have been major concerns. The overuse of fossil fuels poses a major danger to global sustainability. The use of fossil fuels plays an important role in greenhouse gas emissions. Fossil fuels are primarily used in the transportation sector. Road transport plays a critical role in the transportation sector. In this study, carbon dioxide emissions from transport in a specific region were analyzed. Particular emphasis is placed on $CO_2$, one of the most significant greenhouse gases released by the burning of fossil fuels, in this context. The amount of carbon dioxide emissions from transport in this region, called the Black Sea region, was analyzed from 2013 to 2022. Calculations were performed using the IPCC Tier 1 method, which is one of the methods recommended by the IPCC. As a result, it is seen that the highest carbon dioxide emissions come from diesel fuels. The analysis of the Black Sea region's total carbon dioxide emissions reveals consistent growth in all but 2018 and 2022. In addition, it was determined that the amount of carbon dioxide emissions in the region has gradually increased at an alarming level over the years.

*Keywords:* Black Sea Region; Carbon Footprint; Global Warming; Tier 1; Transportation

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## 1. Introduction

The excessive use of fossil fuels seriously threatens the future of the world. The rising levels of various pollutants as well as greenhouse gas emissions are caused by the use of fossil fuels [1]. Globally, fossil fuel usage has grown significantly in recent years, worsening environmental pollution and other issues [2]. Greenhouse gases are gases that trap solar radiation in the Earth's atmosphere, leading to global warming. The carbon footprint refers to the total amount of greenhouse gases, primarily carbon dioxide ($CO_2$), emitted into the atmosphere as a result of human activities, particularly burning fossil fuels like coal, oil, and natural gas. These emissions contribute to the greenhouse effect, leading to global warming and climate change. Calculating a carbon footprint involves assessing the emissions associated with various activities, such as energy consumption, transportation, food production, and more. Both direct emissions (e.g., exhaust emissions from vehicles) and indirect emissions (e.g., emissions from the production and transportation of goods) are taken into account. The carbon footprint is typically expressed in metric tons of $CO_2$ equivalent ($CO_2e$), a unit that standardizes the different greenhouse gases based on their global warming potential. The environmental impacts of the carbon footprint are comprehensive and pose significant challenges for the planet. According to the Intergovernmental Panel on Climate Change (IPCC), using six different emission scenarios as examples, it is anticipated that $CO_2$ concentrations will experience a rise in the upcoming century. These concentrations, which currently stand at 369 parts per million, are projected to increase to a range between 540 and 970 parts per million [3].

The carbon footprint depends on several factors, such as energy consumption, transportation, industrial activities, agricultural and food production, energy sources, product manufacturing and transportation, land use and forest management, consumer behavior, lifestyle choices, and waste management. Among them, the transportation industry plays a vital role in driving economic and industrial advancement by facilitating the movement of countless tons of goods and numerous passengers on a daily basis. Although this industry holds immense significance, it presents a grave risk to human life because of its reliance on petroleum, which is emerging as a major contributor to air pollution. Although fossil fuels are used in many sectors, the lion's share of these sectors are in the transportation sector. Therefore, the transportation sector is the largest producer of greenhouse gases (GHGs) [4]. Approximately 15% of greenhouse gas emissions and 23% of $CO_2$ emissions are

obtained from this sector [5]. Additionally, the transportation sector increased its emissions by 71% from 1990 to 2016, reaching a total of almost 8 Gt $CO_2$. This value is approximately one quarter of all emissions worldwide. Cargo transportation stands out with 42% of this emission amount. It is anticipated that this proportion will increase to 60% by 2050 [5]. Countries are taking action to combat global warming because of this reason. Agreements and protocols have been signed to minimize greenhouse gas emissions, and commitments have been required from certain countries. Depending on the signed agreements and protocols, some regulations have been created to calculate greenhouse gas emissions. Primary and secondary carbon footprints are two main components of the carbon footprint, which may be measured at the individual or institutional level. The main carbon footprint consists of the direct emission of $CO_2$ resulting from the burning of fossil fuels, which includes the energy used at home and for transportation. The additional footprint accounts for the $CO_2$ released during the production of all goods throughout a product's entire life cycle. This additional carbon footprint encompasses the primary footprint. According to the methods suggested by the IPCC, the carbon footprint is measured by converting total greenhouse gas emissions into a standard unit of carbon dioxide equivalent [6]. When the literature is examined, it is seen that studies on carbon footprints are carried out in many different fields. Some of these have been made in recycling facilities [7], university campuses [8], agricultural production [9], wastewater treatment plants [10], textiles [11], and transportation [12–16].

This study aims to determine the greenhouse gases caused by transportation in a specific region and at a certain time. In this context, $CO_2$, which is one of the most important greenhouse gases emitted by the combustion of fossil fuels, is particularly emphasized. The amount of carbon emissions from road transport in the Black Sea region was calculated for the years between 2013 and 2022. Calculations were performed using the IPCC Tier 1 method, which is one of the methods recommended by the IPCC.

## 2. Methodology

### 2.1 Research area

Türkiye is a country located at the intersection of Southeastern Europe and Western Asia. It is regarded as a transcontinental country because it is present on both continents. Türkiye is situated between the Black Sea to the north, the Aegean Sea to the west, the Mediterranean Sea to the south, and the Black Sea to the east. The state of the Republic of Türkiye borders countries such as Greece, Bulgaria, Georgia, Armenia, Azerbaijan, Iran, and Iraq. Türkiye's geography is quite diverse and this diversity has an impact on the country's culture and economy. Türkiye is divided into seven main geographical regions based on its geographical features. These regions include the Mediterranean, Marmara, Black Sea, Aegean, eastern Anatolia, southeastern Anatolia, and the central Anatolia. In this study, a study was conducted on the carbon dioxide emissions of the Black Sea region, which is one of the important regions of Türkiye. In Fig. 1, the Black Sea region is shown on a map of Türkiye.

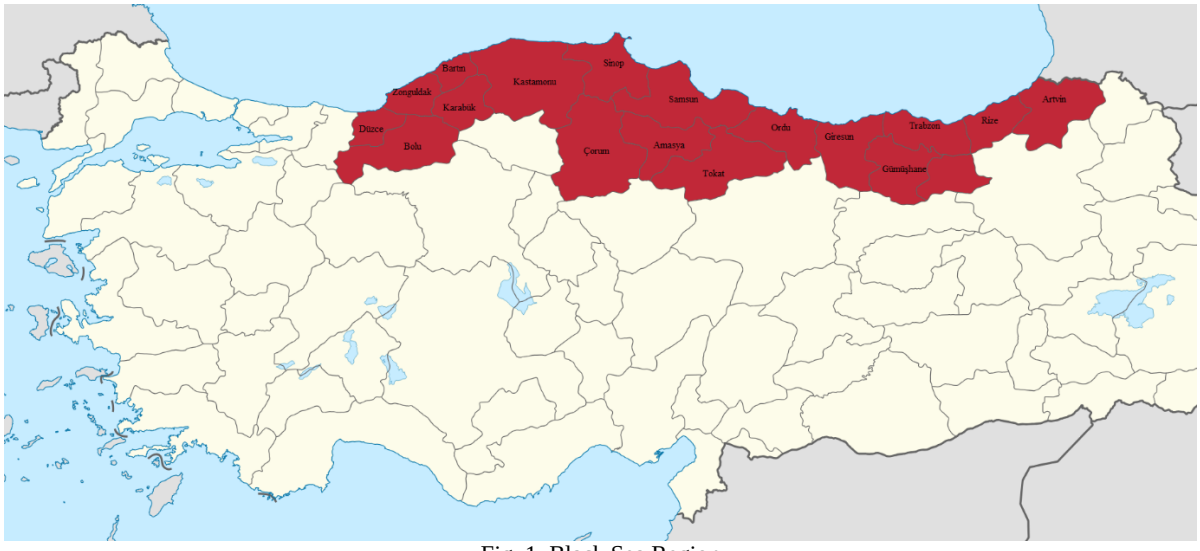


Fig. 1. Black Sea Region

The Black Sea Region is located in the north-eastern part of Türkiye. The region has a humid and rainy climate. This humidity leads to abundant rainfall and rich vegetation cover. Humid climatic conditions create suitable environments for agriculture. A significant source of income is the raising of livestock. The region is noteworthy for its nautical and fishing sectors, in addition to agricultural and animal rearing.

### 2.2 Method

The Tier 1 method is a fuel-based approach, as emissions from all fuel sources are estimated based on the average of the amounts of fuel consumed and emission factors, which are usually derived from national energy statistics. In the Tier 1 calculation method, the emissions resulting from combustion are calculated using the emission factor related to the amount and type of fuel burned [17].

Conversion factors obtained from the IPCC guidelines and currently used in emission calculations were used for the analyses performed in this study. The $CO_2$ emissions are determined by the amount, type, and carbon content of the fuel. The following formulas were used in the analyses using the Tier 1 method:

$$EC = FC \ x \ CF \quad (1)$$

$$CC = CEF \ x \ EC \quad (2)$$

$$CE = CC \ x \ OR \quad (3)$$

$$GGE = CE \ x \ MWR \quad (4)$$

Where $EC$ is the energy consumption at TJ, $FC$ is the fuel consumption, $CF$ is the conversion factor, $CC$ is the carbon content, $CEF$ is the carbon emission factor, $OR$ is the oxidation ratio, $CE$ is the carbon emission, $MWR$ is the molecular weight ratio, and $GGE$ is the greenhouse gas emission. The fuel conversion factor, carbon emission factor, and oxidation rate are presented in Table 1.

Table 1. Conversion factor, carbon emission factor and oxidation rate for fuel types [17]

| Fuel Type | Conversion Factor (TJ/Gg) | Carbon Emission Factor (kg/TJ) | Oxidation Rate (-) |
|---|---|---|---|
| Gasoline | 44.3 | 18.9 | 0.99 |
| Diesel | 43.0 | 20.2 | 0.99 |
| LPG | 47.3 | 17.2 | 0.995 |

## 3. Results and Discussion

This study employed the IPCC Tier 1 methodology to compute the quantities of $CO_2$ discharged due to the utilization of gasoline, diesel, and LPG fuels in road transport within the Black Sea Region with 18 provinces from 2013 to 2022. Fuel usage amounts in the Black Sea Region were taken from the Energy Market Regulatory Authority (EPDK) data for the period 2013-2022. The quantities of fuel utilized for transportation during these specified years have been presented in Table 2.

Table 2. Fuel consumption amounts between 2013-2022 [18]

| | | Cities | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gasoline | Years | Amasya | Artvin | Bartın | Bayburt | Bolu | Çorum | Düzce | Gümüşhane | Giresun | Karabük | Kastamonu | Ordu | Rize | Samsun | Sinop | Tokat | Trabzon | Zonguldak |
| | 2013 | 5720 | 2737 | 3736 | 952 | 11004 | 8364 | 9476 | 1615 | 6224 | 4746 | 7855 | 9927 | 5063 | 21105 | 4824 | 8045 | 12660 | 11018 |
| | 2014 | 6004 | 3044 | 4025 | 1010 | 11563 | 8516 | 9886 | 1669 | 6455 | 5156 | 8098 | 10195 | 5640 | 22009 | 4987 | 8557 | 13766 | 11334 |
| | 2015 | 6618 | 3379 | 4355 | 1211 | 13028 | 9518 | 10910 | 1834 | 7963 | 5659 | 9033 | 12351 | 6465 | 25443 | 5423 | 9434 | 15347 | 12419 |
| | 2016 | 7372 | 3757 | 4751 | 1226 | 14033 | 10155 | 13211 | 1913 | 8177 | 6117 | 9546 | 12709 | 6883 | 27829 | 5043 | 10551 | 16477 | 13409 |
| | 2017 | 7850 | 4098 | 4997 | 1321 | 14302 | 10593 | 13103 | 1973 | 8827 | 6231 | 9816 | 14011 | 7356 | 29121 | 5202 | 11150 | 17373 | 13904 |
| | 2018 | 7408 | 4436 | 5116 | 1380 | 14986 | 10947 | 12646 | 2025 | 8805 | 6275 | 9953 | 14649 | 7672 | 28860 | 5246 | 11126 | 18003 | 14207 |
| | 2019 | 7627 | 4610 | 5337 | 1505 | 16055 | 11745 | 13347 | 2223 | 9368 | 6423 | 10422 | 15651 | 7958 | 29994 | 5532 | 11664 | 18763 | 14792 |
| | 2020 | 7950 | 4645 | 5367 | 1462 | 16936 | 12398 | 13161 | 2395 | 10218 | 6235 | 10593 | 17235 | 8290 | 30912 | 5696 | 12582 | 19146 | 14536 |
| | 2021 | 10338 | 5595 | 6451 | 1865 | 23237 | 15857 | 16621 | 2869 | 12437 | 7835 | 13340 | 20819 | 10373 | 40265 | 6897 | 15481 | 25012 | 18658 |
| | 2022 | 10254 | 5531 | 6489 | 1844 | 23897 | 15464 | 17610 | 2761 | 12842 | 7763 | 12671 | 21298 | 10978 | 42345 | 6859 | 15131 | 28065 | 19154 |
| | | Cities | | | | | | | | | | | | | | | | | |
| Diesel | Years | Amasya | Artvin | Bartın | Bayburt | Bolu | Çorum | Düzce | Gümüşhane | Giresun | Karabük | Kastamonu | Ordu | Rize | Samsun | Sinop | Tokat | Trabzon | Zonguldak |
| | 2013 | 95161 | 33550 | 33816 | 13061 | 118973 | 151587 | 99712 | 33334 | 70168 | 52045 | 81781 | 108420 | 54270 | 261032 | 35741 | 102475 | 162613 | 84703 |
| | 2014 | 83987 | 33266 | 38346 | 13282 | 129619 | 142158 | 92450 | 31079 | 76785 | 55451 | 81112 | 103405 | 60243 | 269035 | 36722 | 102747 | 179350 | 86148 |
| | 2015 | 90449 | 34501 | 45538 | 16094 | 144660 | 154349 | 133085 | 31363 | 94854 | 62818 | 103547 | 111315 | 69407 | 317567 | 49193 | 103488 | 207200 | 103719 |
| | 2016 | 95323 | 45319 | 39479 | 16270 | 143250 | 158870 | 143061 | 37932 | 100621 | 72546 | 118489 | 118578 | 73144 | 428885 | 43788 | 110529 | 235834 | 97717 |
| | 2017 | 91551 | 54384 | 42041 | 19747 | 147835 | 152804 | 130171 | 40998 | 109122 | 95520 | 124291 | 139147 | 79058 | 517046 | 44908 | 148874 | 266281 | 103120 |
| | 2018 | 97285 | 55062 | 39303 | 17795 | 151512 | 149894 | 118694 | 37504 | 103887 | 89036 | 100762 | 142044 | 87677 | 447338 | 45668 | 148669 | 239318 | 99764 |
| | 2019 | 87621 | 65403 | 35810 | 17581 | 155410 | 163432 | 104246 | 29502 | 103646 | 83205 | 93891 | 133332 | 81323 | 402209 | 41318 | 150888 | 231091 | 103131 |
| | 2020 | 95592 | 59163 | 34554 | 16725 | 135658 | 177288 | 110200 | 29680 | 115967 | 128119 | 107935 | 146599 | 87760 | 413109 | 41644 | 153688 | 204644 | 117344 |
| | 2021 | 134275 | 68939 | 37644 | 18313 | 188078 | 179265 | 138345 | 30853 | 125923 | 106999 | 118674 | 165562 | 91177 | 442915 | 50961 | 161196 | 218896 | 156160 |
| | 2022 | 144251 | 54730 | 34616 | 15670 | 203443 | 160862 | 140738 | 23230 | 107341 | 91634 | 104583 | 160162 | 87172 | 447652 | 44603 | 130564 | 196488 | 186664 |
| | | Cities | | | | | | | | | | | | | | | | | |
| LPG | Years | Amasya | Artvin | Bartın | Bayburt | Bolu | Çorum | Düzce | Gümüşhane | Giresun | Karabük | Kastamonu | Ordu | Rize | Samsun | Sinop | Tokat | Trabzon | Zonguldak |
| | 2013 | 16933 | 2935 | 8119 | 2111 | 21401 | 28128 | 19394 | 3491 | 13937 | 11453 | 20049 | 21333 | 8975 | 45799 | 9339 | 21671 | 19109 | 21664 |
| | 2014 | 20693 | 5978 | 13075 | 2966 | 27838 | 34937 | 25351 | 5604 | 23007 | 15663 | 26773 | 33657 | 14200 | 63224 | 13963 | 28450 | 35645 | 33778 |
| | 2015 | 21953 | 6398 | 13375 | 3119 | 29167 | 38166 | 27854 | 5797 | 24850 | 16282 | 28363 | 35756 | 14976 | 67081 | 14766 | 30684 | 36984 | 35823 |
| | 2016 | 22681 | 6671 | 13396 | 3137 | 28172 | 40982 | 28848 | 5666 | 25018 | 16422 | 29284 | 35737 | 14609 | 67403 | 15209 | 31495 | 36854 | 37093 |
| | 2017 | 24527 | 7702 | 13589 | 3054 | 27538 | 41288 | 28828 | 5504 | 24346 | 16324 | 29001 | 38455 | 13949 | 72155 | 14820 | 32273 | 37804 | 36324 |
| | 2018 | 27896 | 6619 | 13478 | 3138 | 27857 | 42504 | 29312 | 5649 | 24569 | 16594 | 29424 | 38621 | 14263 | 72558 | 15243 | 33335 | 34125 | 35699 |
| | 2019 | 27159 | 7130 | 13532 | 3338 | 28493 | 42617 | 30076 | 5328 | 24248 | 16480 | 29566 | 39252 | 14174 | 73652 | 14952 | 34409 | 34182 | 35977 |
| | 2020 | 25758 | 6682 | 12733 | 3057 | 25588 | 39551 | 27991 | 5095 | 24337 | 14887 | 27284 | 37932 | 13561 | 68394 | 13354 | 33005 | 31883 | 32626 |
| | 2021 | 25342 | 6751 | 12356 | 3169 | 25909 | 38548 | 27750 | 5033 | 24312 | 14600 | 27949 | 37549 | 13287 | 69674 | 14646 | 32641 | 31354 | 32478 |
| | 2022 | 24030 | 6255 | 12402 | 2917 | 25998 | 36496 | 32594 | 4789 | 22424 | 14116 | 26780 | 35286 | 12110 | 68405 | 12939 | 34109 | 29350 | 31760 |

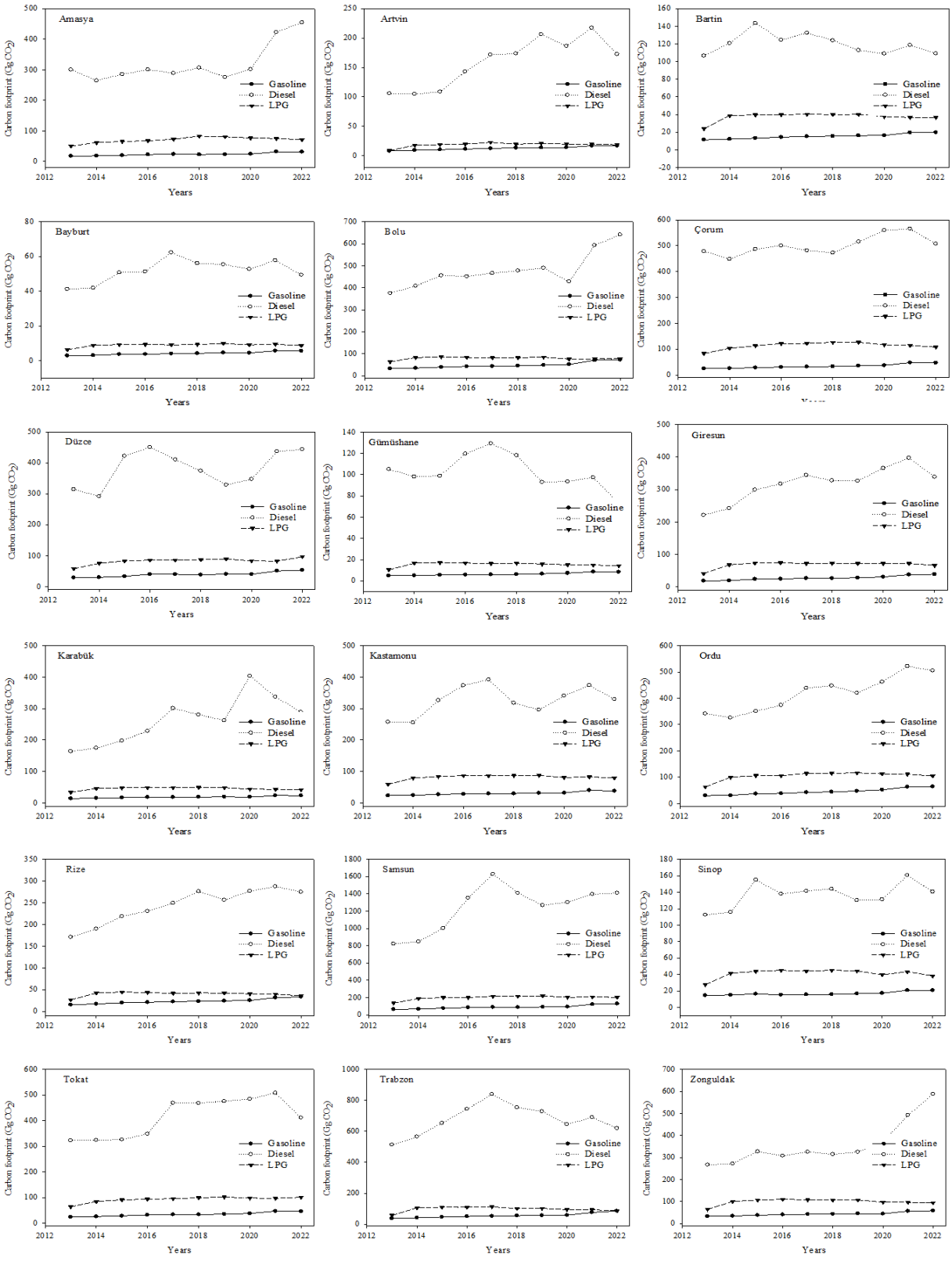


Fig. 2. Variation of carbon footprint by year in terms of fuel type

Between 2013 and 2022, the highest increase in gasoline consumption was in Trabzon Province with 121%, Zonguldak Province with a 120 % increase in diesel consumption, and Artvin Province with a 131% increase in LPG consumption. The variation of carbon dioxide emissions according to fuel type based on the provinces is shown in Figure 2. Based on the data presented in Figure 2, it can be inferred that diesel-fueled vehicles have significantly higher excess $CO_2$ emissions per year than other fuel types. This is followed by LPG and gasoline, respectively. It has been observed that $CO_2$ emissions from gasoline vehicles have increased at particular rates over the years. When the province of Amasya is examined, there has been an increase in the amount of $CO_2$ emissions by an average of 7% for gasoline, 5.6% for diesel, and 4.32% for LPG every year from 2013 to 2022. Gasoline, diesel, and LPG emit more $CO_2$ in the Artvin province every year from 2013 to 2022. The annual increase rates for these fuels are 8.3%, 6.7% and 12.3%, respectively. From 2013 to 2022, the province of Bartın saw a yearly increase in $CO_2$ emissions by an average of 6.4 % for gasoline, 0.8 % for diesel and 6.2 % for LPG. The amount of $CO_2$ emissions from gasoline, diesel and LPG in the province of Bayburt has risen by an average of 8 %, 2.7 % and 4.4 % respectively each year from 2013 to 2022. From 2013 to 2022, the province of Bolu saw a yearly increase in $CO_2$ emissions of 9.4 % for gasoline, 6.8 % for diesel and 2.6 % for LPG. When the province of Çorum is examined, there has been an increase in the amount of $CO_2$ emissions by an average of 7.3 % for gasoline, 0.8 % for diesel and 3.3 % for LPG every year from 2013 to 2022. Gasoline, diesel and LPG have been emitting more $CO_2$ in Düzce province every year from 2013 to 2022. The annual increase rates are 7.5 %, 5.2 % and 6.4 % respectively for these fuels. From 2013 to 2022, there was an annual average increase of 6.3 % for gasoline and 5 % for LPG in $CO_2$ emissions in Gümüşhane province, while a decrease of 2.9 % was observed for diesel. The amount of $CO_2$ emissions from gasoline, diesel and LPG in the province of Giresun has risen by an average of 8.6 %, 5.3 % and 7 % respectively, each year from 2013 to 2022. From 2013 to 2022, the province of Karabük saw a yearly rise in $CO_2$ emissions by 5.9 % for gasoline, 8.5 % for diesel, and 3 % for LPG on average. Gasoline, diesel and LPG emissions of $CO_2$ increased annually by 5.7 %, 3.7 % and 3.8 %, respectively, in the province of Kastamonu from 2013 to 2022. From 2013 to 2022, the province of Ordu saw a yearly increase in $CO_2$ emissions by an average of 9 % for gasoline, 4.7 % for diesel, and 7 % for LPG. The amount of $CO_2$ emissions from gasoline, diesel and LPG in the province of Rize increased by an average of 9.1 %, 5.6 % and 4.7 %, respectively, each year from 2013 to 2022. When the province of Samsun is examined, there has been an increase in the amount of $CO_2$ emissions by an average of 8.3 % for gasoline, 7.1 % for diesel and 5.1 % for LPG every year from 2013 to 2022. Gasoline, diesel and LPG emissions of $CO_2$ have increased annually by 4.2 %, 3.4 % and 4.8 %, respectively, in the province of Sinop from 2013 to 2022. The amount of $CO_2$ emissions from gasoline, diesel and LPG in the province of Tokat has risen by an average of 7.4 %, 3.5 % and 5.5 % respectively each year from 2013 to 2022. Within the same year, the province of Trabzon saw a yearly rise in $CO_2$ emissions by 9.5 % for gasoline, 2.6 % for diesel and 7.5 % for LPG on average. The amount of $CO_2$ emissions from gasoline, diesel and LPG in the province of Zonguldak has risen by an average of 6.6 %, 9.8 % and 5.6 % respectively, each year from 2013 to 2022. When all provinces are examined, it is seen that the emissions caused by diesel fuels have decreased over the years only for the Gümüşhane province. Other fuel types and amounts of carbon dioxide emissions in the provinces have increased continuously. The changes in total carbon dioxide emissions by province are shown in Figure 3. The total annual rate of carbon dioxide emissions has increased, although the total annual rate of carbon dioxide emissions has decreased in some years. When the carbon dioxide emissions from 2013 to 2022 are analyzed, Samsun province made the highest contribution with a 15333.4 Gg $CO_2$ value. This is followed by Trabzon province with 8285.38 Gg $CO_2$ value and Çorum province with 6497.46 Gg $CO_2$ value. Bayburt province made the lowest contribution with a 649.695 Gg $CO_2$ value. This is followed by Gümüşhane province with 1245.09 Gg $CO_2$ and Artvin province with 1904.58 Gg $CO_2$. The Black Sea region has contributed a total of 83836.68 Gg $CO_2$ to carbon dioxide emissions in the last 10 years. When 2013 is taken as a reference, in 2014, carbon emissions decreased in Amasya Çorum, Düzce and Gümüşhane whereas they increased in other provinces. Carbon dioxide emissions gradually increased in all provinces from 2014 to 2015. In 2016, carbon dioxide emissions decreased in Bartın, Bolu, Sinop, and Zonguldak, but increased in other provinces. Only three provinces, Amasya, Çorum and Düzce, reduced their carbon dioxide emissions in 2017. The rest of the provinces increased them. When the year 2018 is examined, it is seen that carbon dioxide emissions have increased in provinces such as Amasya, Bolu, Ordu, Rize, Sinop, and Tokat, while it has decreased in other provinces. A review of 2019 shows that provinces like Artvin, Bayburt, Bolu, Çorum, Tokat, and Zonguldak had a rise in carbon dioxide emissions, while other provinces experienced a decline. In 2020, carbon dioxide emissions decreased in Artvin, Bartın, Bayburt, Bolu, Sinop and Trabzon while it increased in other provinces. In 2021, the amount of carbon dioxide emissions gradually increased in all provinces. In 2022, some provinces, such as Amasya, Bolu, Düzce, Samsun, and Zonguldak saw an increase in the amount of carbon dioxide they released, while others reduced their emissions.

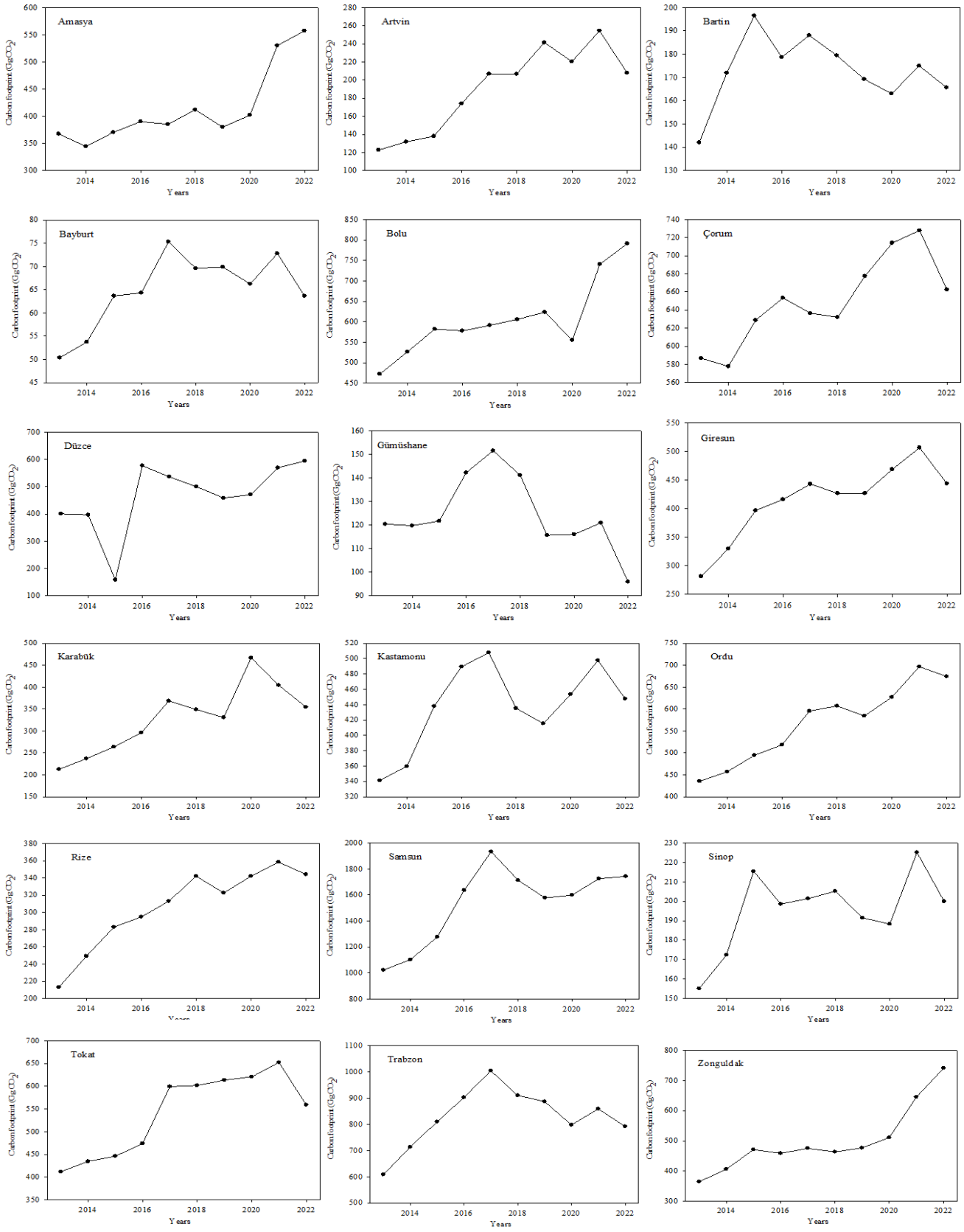


Fig. 3. Changes in total $CO_2$ emission by provinces

## 4. Conclusion

Global warming is one of the most important situations affecting all countries in the world. The spread of greenhouse gases threatens the world in a very serious way. One of the most important sources of greenhouse gases is the transportation sector. The rising consumption of fossil fuels such as gasoline, diesel, and liquefied petroleum gas (LPG) is still contributing to the growth of emissions. The evaluation of the carbon footprint in the Black Sea region of Turkey between 2013 and 2022 is presented in this study. The calculation was conducted utilizing the Tier 1 methodology as advised by the Intergovernmental Panel on Climate Change (IPCC). It is seen that diesel fuel has the largest consumption share among fuels compared to other fuels. Additionally, it is seen that the highest carbon dioxide emissions are also caused by diesel fuels. Diesel vehicles emitting excess carbon dioxide emissions are followed by LPG and gasoline vehicles, respectively. When the total carbon dioxide emission of the Black Sea region is analyzed, it is seen that it has increased continuously in all years except 2018 and 2022. The leading contributor to $CO_2$ emissions was Samsun Province, accounting for a substantial 15333.4 Gg $CO_2$ emissions. Trabzon province followed with 8285.38 Gg $CO_2$ emission, and Çorum province ranked third with 6497.46 Gg $CO_2$ emissions. On the other hand, Bayburt province was the smallest contribution, emitting only 649.69 Gg of $CO_2$. Gümüşhane province followed with 1,245.09 Gg $CO_2$ emissions, and Artvin province followed with 1904.58 Gg $CO_2$ emissions. While the total amount of carbon dioxide emissions in the Black Sea Region was approximately 6310 Gg of $CO_2$ in 2013, this amount increased to approximately 9438 Gg of $CO_2$ in 2022. As can be seen from the results presented, carbon dioxide emissions are increasing day by day at an alarming rate. Carbon footprint can be reduced by increasing the use of electric or hybrid vehicles, increasing public transportation options, and increasing the use of vehicles with more efficient engines in road transportation. Efforts to reduce the carbon footprint in road transportation promote the adoption of eco-friendly options and the transition to a more sustainable transportation system.

## Conflict of Interest Statement

The author declares that there is no conflict of interest in the study.

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