Creation of carbon footprint originating from road transportation in Turkey and digital mapping of it

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Abstract: In this study, the carbon footprint created by the greenhouse gases originating from road transportation in Turkey was calculated. In emission calculations, the methodology recommended by the Intergovernmental Panel on Climate Change and determined by the tier-1 and tier-2 approaches was used. As a result of the study, it was observed that the CO₂ emission, which was 95,689 GgCO₂ in 2018 according to the tier 1 method, decreased to 92,424 GgCO₂ in 2020, and the CO₂ emission, which was 417,359 GgCO₂ in 2018 in the tier-2 method, decreased to 404,631 GgCO₂ in 2020. Among the fuels used, it was determined that the diesel fuel type had the highest CO₂ emission in both methods. Among the provinces, it was determined that Istanbul, Ankara and Izmir have the highest CO₂ emissions, respectively. CO₂ emissions were calculated for each province and presented visually on maps prepared using the ARCGIS method.

Keywords: carbon footprint; greenhouse gases; road transportation; carbon dioxide; global warming.

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1 Introduction

Human activities such as energy production, industrialisation, transportation and agricultural activities cause greenhouse gas emissions such as carbon dioxide (CO_2), methane (CH_4) and dinitrogen monoxide (N_2O) to be released into the atmosphere. Due to the increase in global greenhouse gas emissions, a significant increase in the average temperature of the earth's surface has been observed (Güzel and Alp, 2020). Greenhouse gas emission producers in Turkey are energy industries, transportation, manufacturing industry, construction, waste and forestry applications. The most significant increase in the amount of carbon dioxide in Turkey was observed in the energy sector in 2012 with 250%. While it was 136% in the transportation sector, 123% in the public and agricultural sector and 49% in the manufacturing sector. When greenhouse gas emission statistics are examined in the 2016 results, 72.8% of total emissions are caused by energy emissions, 12.6% by industrial processes and product use, 11% by agricultural activities and 3.3% by waste. Compared to 1990, it is known that the total share of the energy sector increased from 64% to 73% (Baycan and Zengin, 2021).

The transportation sector emits significant amounts of carbon through direct fuel combustion and is a significant contributor to overall CO₂ emissions (Li et al., 2021). Three-quarters of these emissions are from road transport due to the high dependence on traditional fossil fuels such as gasoline and diesel (Navas-Anguita et al., 2020). Road vehicles are a major contributor to greenhouse gas emissions in the transport sector. Therefore, reducing emissions from transportation is an important element in any comprehensive strategy to reduce global greenhouse gas emissions (La Notte et al., 2018). Greenhouse gas emissions from transportation are the result of dynamic interactions between human behaviour, vehicle technology and fuel technology (Kay et al., 2014). Transport is Europe's largest source of carbon emissions, contributing 27% to total CO₂ emissions, with cars and vans accounting for more than two-thirds of these, according to the European environment agency. Similar to the European Union, a significant portion of greenhouse gas emissions in Turkey originate from the transportation sector due to the use of fossil fuels (Coşkun and Oktay, 2020). The increasing number of vehicles, traffic congestion, high emission amount of existing vehicles, lack of regular vehicle maintenance and polluted gas control, low fuel quality and population growth along the highways are considered the causes of the continuous increase in greenhouse gas emissions originating from road transportation (Dündar, 2021).

Wiedmann and Minx (2008) have defined carbon footprint as "a measure of the total amount of carbon dioxide emissions caused directly or indirectly by an activity or accumulated during the life stages of a product" (Zhao et al., 2022; Pandey et al., 2011). The carbon footprint, which is a quantitative expression of greenhouse gas emissions from an activity, helps in emission management and evaluation of mitigation measures (Pandey et al., 2011). The carbon footprint (CF) is used as an indicator to measure greenhouse gas emissions in CO_2 equivalents (CO_2 -eq) (Zhao et al., 2022).

In this study, Turkey's carbon footprint calculations originating from road transportation were made separately for each province and visually presented with maps using the ARCGIS method and comparisons were made. The study was conducted for 2018 and 2020. In the study, tier-1 and tier-2 methods developed by the IPCC were used to calculate greenhouse gas emissions. The data on the amount of fuel used in the study were obtained from the Energy Market Regulatory Authority (EMRA) reports.

2 Materials and method

2.1 Study area

Turkey (Figure 1) is located in the middle belt of the Northern Hemisphere, where land masses occupy a large area, between 36–42 degrees north parallels and 26–45 degrees east meridians (Balcı, 2012; Çelik, 2020a; Kaya, 2017). Turkey's surface area is 779,452 km². Turkey, whose population exceeded 83 million at the last census, is among the most populous countries in the world. Turkey, which has land in both Asia and Europe, is considered as a land bridge connecting the two continents. The fact that Turkey is located in the central climate zone of the northern hemisphere has brought the chance to have the effect of the subtropical middle zone climate, which is most suitable for people's life. Towards the north of this area, the harsh continental climate and lush vegetation limit human activities in places, while towards the south, the extremely hot tropical climate and large deserts on large land masses limit their habitats (Çelik, 2020a).

18 19 40 43 49 38 13 68 42 62 63 125 500 km Province names: 1 Adana 12 Bingöl 23 Elazığ 34 İstanbul 45 Manisa 67 Zonguldak 78 Karabük 56 Siirt 2 Adıyaman 13 Bitlis 24 Erzincan 35 İzmir 46 Kahramanmaraş 57 Sinop 68 Aksaray 79 Kilis 14 Bolu 47 Mardin 58 Sivas 3 Afyon 25 Erzurum 36 Kars 69 Bayburt 80 Osmanive 15 Burdur 26 Eskişehir 37 Kastamonu 48 Muğla 59 Tekirdağ 70 Karaman 81 Düzce 4 Ağrı 49 Muş 5 Amasya 16 Bursa 27 Gaziantep 38 Kayseri 60 Tokat 71 Kırıkkale 6 Ankara 17 Canakkale 28 Giresun 39 Kırklareli 50 Nevsehir 61 Trabzon 72 Batman 7 Antalya 18 Çankırı 29 Gümüşhar e 40 Kırşehir 51 Niğde 62 Tunceli 73 Sırnak 8 Artvin 19 Çorum 30 Hakkari 41 Kocaeli 52 Ordu 63 Şanlıurfa 74 Bartın 9 Avdın 20 Denizli 31 Hatay 42 Konya 53 Rize 64 Usak 75 Ardahan 10 Balıkesir 21 Diyarbakır 32 Isparta 43 Kütahya 54 Sakarya 65 Van 76 Iğdır

Figure 1 Maps of Turkey (see online version for colours)

Source: Muratoğlu (2020)

2.2 IPCC methodology

In this study, tier-1 and tier-2 approaches, which are from the tier approaches recommended by the Intergovernmental Panel on Climate Change (IPCC), were used. The tier-1 approach is a simpler method that requires less data. Tier-2 and tier-3 approaches are more complex and require more data (IPCC, 2006). Tier-3 approach was not used because data belonging to tier-3 approach could not be reached.

2.2.1 Tier-1 approach

The tier-1 method is a fuel-based approach, as emissions from all fuel sources are estimated based on the amounts of fuel burned and average emission factors, usually derived from national energy statistics. In the tier-1 calculation method, emissions resulting from combustion are calculated using the amount of fuel consumed and the emission factor depending on the fuel type (IPCC, 2006). Tier-1 equations are given below (Dündar, 2021):

Energy consumption (TJ) = Fuel consumption (t)

$$\times$$
 Conversion factor (TJ/kt) \times 10⁻³ (1)

Carbon content (Gg C) = Carbon emission factor (tC/TJ)
× Energy consumption×
$$10^{-3}$$
 (2)

Carbon emission (Gg C) = Carbon content (GgC)

$$\times$$
 Carbon oxidation rate (3)

$$CO_2$$
 emission (Gg C) = Carbon emission (GgC)
 \times Molecular weight ratio (44/12) (4)

Conversion factors in equation (1), carbon emission factors in equation (2) and carbon oxidation rates in equation (3) were obtained from the IPCC guideline and are presented in Table 1. Fuel consumptions are obtained from EMRA reports for each province and presented in Table 2.

Table 1 Fuel data used in tier-1 approach

| Fuel | Conversion factor (TJ/kt) | C emission factor (tC/TJ) | C oxidation rate (%) |
|----------|---------------------------|---------------------------|----------------------|
| Gasoline | 44,3 | 18,90 | 0,99 |
| Diesel | 43,0 | 20,20 | 0,99 |
| LPG | 47,3 | 17,20 | 0,99 |

Source: IPCC (2006)

 Table 2
 Annual fuel consumptions

| Provinces | | 2018 | | | 2020 | |
|----------------|----------|-----------|---------|----------|-----------|---------|
| Provinces | Gasoline | Diesel | LPG | Gasoline | Diesel | LPG |
| Adana | 51,536 | 544,922 | 133,739 | 52,914 | 563,120 | 129,955 |
| Adıyaman | 7,295 | 125,442 | 36,386 | 7,836 | 99,000 | 33,362 |
| Afyonkarahisar | 18,779 | 236,793 | 57,331 | 20,449 | 292,981 | 54,245 |
| Ağrı | 4,005 | 74,782 | 11,738 | 4,239 | 74,893 | 11,085 |
| Aksaray | 8,972 | 137,404 | 29,514 | 10,406 | 146,798 | 28,342 |
| Amasya | 7,408 | 97,285 | 27,896 | 7,950 | 95,592 | 28,342 |
| Ankara | 205,827 | 2,065,451 | 401,524 | 196,172 | 2,029,160 | 354,879 |
| Antalya | 98,040 | 722,051 | 156,810 | 96,156 | 653,274 | 150,731 |
| Ardahan | 1,795 | 22,867 | 2,855 | 1,882 | 110,324 | 3,298 |

Source: EMRA (2018a, 2018b, 2020a, 2020b)

 Table 2
 Annual fuel consumptions (continued)

| ъ : | | 2018 | | | 2020 | |
|---------------|----------|-----------|---------|----------|-----------|---------|
| Provinces | Gasoline | Diesel | LPG | Gasoline | Diesel | LPG |
| Artvin | 4,436 | 55,142 | 6,619 | 4,645 | 59,220 | 6,682 |
| Aydın | 41,231 | 301,557 | 76,666 | 41,993 | 546,217 | 70,529 |
| Balıkesir | 50,131 | 414,970 | 78,549 | 53,559 | 420,410 | 75,351 |
| Bartın | 5,116 | 39,303 | 13,478 | 5,367 | 34,724 | 12,733 |
| Batman | 5,893 | 102,587 | 12,479 | 5,564 | 166,801 | 11,216 |
| Bayburt | 1,380 | 17,795 | 3,138 | 1,462 | 16,725 | 3,057 |
| Bilecik | 6,522 | 80,824 | 12,021 | 6,889 | 76,417 | 11,700 |
| Bingöl | 2,674 | 34,955 | 7,763 | 2,995 | 33,513 | 6,581 |
| Bitlis | 2,954 | 52,506 | 9,385 | 3,076 | 59,595 | 8,825 |
| Bolu | 14,986 | 151,512 | 27,857 | 16,936 | 135,658 | 25,588 |
| Burdur | 8,176 | 154,978 | 24,860 | 8,277 | 126,356 | 22,179 |
| Bursa | 108,096 | 856,326 | 118,491 | 110,566 | 828,134 | 111,296 |
| Çanakkale | 25,620 | 185,699 | 30,722 | 27,132 | 204,104 | 27,509 |
| Çankırı | 4,321 | 71,955 | 13,910 | 5,090 | 134,314 | 12,732 |
| Çorum | 10,947 | 149,894 | 42,504 | 12,398 | 177,288 | 39,551 |
| Denizli | 30,641 | 439,462 | 76,801 | 30,230 | 583,449 | 71,129 |
| Diyarbakır | 18,132 | 197,822 | 46,612 | 18,746 | 191,793 | 46,303 |
| Düzce | 12,646 | 118,694 | 29,312 | 13,161 | 110,200 | 27,991 |
| Edirne | 21,472 | 355,743 | 20,852 | 20,455 | 535,045 | 19,311 |
| Elazığ | 10,702 | 136,176 | 26,372 | 12,069 | 123,758 | 27,320 |
| Erzincan | 5,855 | 69,139 | 12,656 | 6,450 | 66,779 | 11,811 |
| Erzurum | 14,086 | 143,879 | 27,471 | 14,342 | 137,936 | 25,568 |
| Eskişehir | 28,761 | 345,633 | 45,097 | 27,708 | 309,024 | 40,201 |
| Gaziantep | 42,055 | 545,352 | 95,851 | 41,593 | 590,711 | 89,342 |
| Giresun | 8,805 | 103,887 | 24,569 | 10,218 | 116,086 | 24,337 |
| Gümüşhane | 2,025 | 37,504 | 5,649 | 2,395 | 29,880 | 5,095 |
| Hakkari | 1,611 | 24,836 | 3,790 | 1,833 | 26,612 | 4,143 |
| Hatay | 37,680 | 444,739 | 84,985 | 38,866 | 438,939 | 83,378 |
| Iğdır | 2,423 | 23,990 | 4,050 | 2,725 | 28,125 | 3,858 |
| Isparta | 13,344 | 114,669 | 30,565 | 13,166 | 98,975 | 28,080 |
| İstanbul | 542,808 | 3,971,717 | 335,153 | 510,329 | 3,439,428 | 299,546 |
| İzmir | 148,903 | 1,349,316 | 251,584 | 147,928 | 1,136,952 | 214,551 |
| Kahramanmaraş | 18,738 | 208,765 | 81,428 | 20,595 | 197,061 | 79,239 |
| Karabük | 6,275 | 89,036 | 16,594 | 6,235 | 128,119 | 14,887 |
| Karaman | 4,602 | 58,017 | 15,660 | 4,965 | 60,484 | 15,266 |
| Kars | 4,463 | 52,816 | 6,837 | 4,501 | 49,589 | 6,603 |

Source: EMRA (2018a, 2018b, 2020a, 2020b)

 Table 2
 Annual fuel consumptions (continued)

| | | 2018 | | | 2020 | |
|------------|----------|-----------|---------|----------|---------|---------|
| Provinces | Gasoline | Diesel | LPG | Gasoline | Diesel | LPG |
| Kastamonu | 9,953 | 100,783 | 29,424 | 10,593 | 107,935 | 27,284 |
| Kayseri | 34,398 | 385,445 | 96,381 | 35,742 | 329,535 | 88,703 |
| Kırıkkale | 6,963 | 206,419 | 33,338 | 7,441 | 160,332 | 29,920 |
| Kırklareli | 16,481 | 141,670 | 16,156 | 16,898 | 153,197 | 16,385 |
| Kırşehir | 4,992 | 49,406 | 17,606 | 5,373 | 51,152 | 17,283 |
| Kilis | 3,835 | 20,177 | 6,803 | 3,910 | 23,250 | 6,868 |
| Kocaeli | 65,429 | 840,748 | 97,175 | 65,557 | 728,916 | 90,415 |
| Konya | 49,384 | 869,020 | 159,677 | 49,398 | 711,522 | 144,954 |
| Kütahya | 14,302 | 210,075 | 43,604 | 14,443 | 237,825 | 39,645 |
| Malatya | 14,900 | 146,073 | 38,184 | 16,478 | 134,461 | 38,422 |
| Manisa | 40,671 | 469,730 | 106,223 | 46,048 | 487,544 | 100,053 |
| Mardin | 7,361 | 130,743 | 19,280 | 7,583 | 172,104 | 17,920 |
| Mersin | 51,226 | 1,251,630 | 116,447 | 52,025 | 898,628 | 115,601 |
| Muğla | 63,375 | 382,852 | 80,014 | 66,430 | 344,561 | 76,805 |
| Muş | 2,578 | 44,055 | 9,772 | 2,879 | 43,375 | 9,471 |
| Nevşehir | 7,571 | 207,058 | 24,858 | 7,923 | 105,253 | 20,824 |
| Niğde | 6,846 | 123,403 | 21,983 | 7,600 | 124,933 | 22,086 |
| Ordu | 14,649 | 142,125 | 38,621 | 17,235 | 146,865 | 37,932 |
| Osmaniye | 9,653 | 116,639 | 38,964 | 10,408 | 89,627 | 40,170 |
| Rize | 7,672 | 87,677 | 14,263 | 8,290 | 87,760 | 13,561 |
| Sakarya | 30,768 | 315,678 | 83,064 | 31,844 | 296,209 | 76,145 |
| Samsun | 28,860 | 453,726 | 72,558 | 30,912 | 424,539 | 68,394 |
| Siirt | 2,183 | 50,881 | 5,575 | 2,230 | 57,712 | 6,536 |
| Sinop | 5,246 | 45,927 | 15,243 | 5,696 | 41,824 | 13,354 |
| Sivas | 12,956 | 181,313 | 34,738 | 13,299 | 146,481 | 33,812 |
| Şanlıurfa | 21,459 | 249,662 | 89,057 | 21,869 | 273,713 | 92,952 |
| Şırnak | 2,146 | 94,855 | 6,065 | 2,697 | 118,172 | 6,798 |
| Tekirdağ | 40,102 | 495,744 | 52,541 | 40,576 | 566,661 | 51,446 |
| Tokat | 11,126 | 148,669 | 33,335 | 12,582 | 153,688 | 33,005 |
| Trabzon | 18,003 | 240,716 | 34,125 | 19,146 | 205,413 | 31,883 |
| Tunceli | 1,167 | 15,092 | 2,782 | 1,350 | 13,345 | 2,696 |
| Uşak | 9,962 | 87,027 | 26,450 | 9,824 | 104,742 | 25,185 |
| Van | 10,329 | 95,443 | 25,053 | 10,162 | 84,716 | 23,565 |
| Yalova | 9,514 | 74,423 | 10,819 | 10,835 | 76,469 | 10,082 |
| Yozgat | 6,622 | 115,653 | 32,443 | 7,273 | 127,640 | 31,165 |
| Zonguldak | 14,207 | 99,890 | 35,699 | 14,536 | 117,602 | 32,626 |

Source: EMRA (2018a, 2018b, 2020a, 2020b)

| Car | | | Minibus | Bus | Small truck | Truck | Motorcycle |
|----------|--------|------|---------|--------|-------------|--------|------------|
| Gasoline | Diesel | LPG | Diesel | Diesel | Diesel | Diesel | Gasoline |
| 8.5 | 7.3 | 11.2 | 10.9 | 29.9 | 10.9 | 29.9 | 4 |

 Table 3
 Average amount of fuel consumed per 100 km by motor vehicle type

Source: IPCC (1996)

2.2.2 Tier-2 approach

In the tier-2 calculation method, the amount of distance travelled by the vehicle is taken into account instead of fuel consumption. In the tier-2 method, emissions from combustion are estimated from similar fuel statistics as used in the tier-1 method, but using country-specific emission factors instead of tier 1 defaults. The tier-2 approach is the same as tier 1, except that the country-specific carbon content of the fuel sold in road transport is used. In tier 2, CO₂ emission factors can be adjusted to account for either unoxidised carbon or carbon emitted from a gas other than CO₂ (IPCC, 2006). Tier-2 calculations are made using equations (5)–(9) (Çelik, 2020b).

Fuel consumption (kt) = Number of vehicles × Range (km)
× Fuel consumption (L/km) × Density (kg/L)×
$$10^{-6}$$
 (5)

Energy consumption (TJ) = Fuel consumption (kt)

$$\times$$
 Conversion factor (TJ/kt) (6)

Content of fuel (tC) = Energy consumption (TJ)
$$\times$$
C emission factor (tC/TJ) (7)

Carbon emission (tC) =
$$C$$
 content of fuel (tC)× C oxidation rate (8)

$$CO_2$$
 emission (Gg CO₂) = C emission (t)
× Molecular weight ratio (44/12)×10⁻³ (9)

The annual range data of the vehicles in equation (5) were found on average with the help of the fuel consumption values at 100 km and the number of vehicles given in Table 3 as reported by Bıyık and Civelekoğlu (2020) and presented in Table 4. The number of vehicles and the distribution of registered automobiles by fuel type were obtained from the Turkish Statistical Institute (TSI) for 2018 and 2020 (TSI, 2018, 2020, 2022), and they were proportioned to the provinces. The densities of fuels are shown in Table 5. The following steps were followed while calculating the annual range of the vehicles (Bıyık, 2018).

- the total volume of fuels was calculated with the help of the amount of fuel consumed by the vehicles and the densities of the fuels
- the fuel volume consumed by 1 vehicle was found by dividing the total fuel volume by the total number of vehicles
- the average annual range of the vehicles in km was found by dividing the fuel volume consumed by 1 vehicle by the fuel consumption of the vehicle at 100 km.

Table 4 Average annual range of vehicles (km)

| | | | | | 2018 | | | |
|----------------|----------|---------|--------|-----------|-----------|-------------|---------|------------|
| Provinces | | Car | | Minibus | Bus | Small truck | Truck | Motorcycle |
| | Gasoline | Diesel | DAT | Diesel | Diesel | Diesel | Diesel | Gasoline |
| Adana | 9,714 | 74,095 | 17,368 | 542,243 | 459,557 | 59,902 | 110,395 | 12,989 |
| Adıyaman | 9,339 | 115,850 | 32,093 | 296,781 | 1,302,752 | 89,995 | 146,131 | 17,470 |
| Afyonkarahisar | 13,215 | 120,212 | 27,797 | 539,330 | 565,930 | 75,833 | 98,887 | 15,743 |
| Ağrı | 25,550 | 344,130 | 51,590 | 334,248 | 886,277 | 110,389 | 139,895 | 106,255 |
| Aksaray | 8,679 | 95,880 | 19,669 | 1,087,950 | 391,009 | 87,166 | 88,403 | 22,465 |
| Amasya | 7,912 | 74,964 | 20,529 | 354,895 | 539,959 | 63,247 | 111,557 | 19,840 |
| Ankara | 8,875 | 64,248 | 11,928 | 904,920 | 466,599 | 76,988 | 103,322 | 138,167 |
| Antalya | 12,214 | 64,893 | 13,460 | 544,748 | 268,280 | 43,632 | 124,295 | 11,573 |
| Ardahan | 28,592 | 262,697 | 31,319 | 320,762 | 1,842,868 | 87,129 | 190,379 | 127,015 |
| Artvin | 17,454 | 156,512 | 17,944 | 275,793 | 694,355 | 45,390 | 65,738 | 91,891 |
| Aydın | 14,133 | 74,569 | 18,106 | 319,826 | 400,633 | 48,716 | 136,102 | 10,657 |
| Balıkesir | 15,010 | 89,631 | 16,204 | 724,160 | 464,607 | 67,310 | 135,077 | 14,380 |
| Bartın | 10,868 | 60,238 | 19,729 | 283,568 | 262,636 | 56,309 | 99,729 | 34,525 |
| Batman | 24,280 | 304,917 | 35,423 | 409,214 | 1,440,324 | 95,958 | 154,186 | 30,475 |
| Bayburt | 12,946 | 120,392 | 20,275 | 339,126 | 640,216 | 69,136 | 106,228 | 38,384 |
| Bilecik | 12,134 | 108,470 | 15,407 | 856,548 | 384,510 | 76,423 | 102,868 | 29,057 |
| Bingöl | 21,847 | 206,034 | 43,700 | 289,855 | 582,037 | 80,128 | 122,481 | 141,643 |
| Bitlis | 23,326 | 299,101 | 51,061 | 367,088 | 1,330,639 | 93,487 | 118,860 | 183,001 |
| Bolu | 16,565 | 120,818 | 21,215 | 1,083,962 | 609,299 | 101,369 | 102,025 | 43,795 |
| Burdur | 9,278 | 126,875 | 19,438 | 1,264,228 | 660,799 | 109,592 | 108,511 | 8,012 |
| Bursa | 13,535 | 77,352 | 10,222 | 642,368 | 406,810 | 56,392 | 122,235 | 36,214 |
| Çanakkale | 17,967 | 90,760 | 14,340 | 788,554 | 391,562 | 61,788 | 125,718 | 14,798 |
| Çankırı | 12,231 | 146,927 | 27,126 | 1,067,579 | 569,631 | 96,406 | 151,882 | 31,406 |
| Çorum | 8,313 | 82,110 | 22,236 | 606,456 | 525,216 | 74,865 | 104,915 | 20,685 |
| Denizli | 9,748 | 100,861 | 16,834 | 962,689 | 437,561 | 76,356 | 145,806 | 14,315 |
| Diyarbakır | 21,954 | 172,790 | 38,884 | 363,344 | 573,883 | 94,794 | 116,556 | 61,117 |
| Dijze | 13 901 | 94 128 | 22 201 | 508 516 | 703 177 | 76 549 | 103 033 | 001.20 |

 Table 4
 Average annual range of vehicles (km) (continued)

| Car Gasoline Diesel 19,402 231,893 9,452 86,765 14,838 109,335 12,903 109,930 10,724 92,970 11,397 106,622 13,079 111,332 46,444 516,627 11,165 95,069 23,357 166,838 10,195 63,200 11,686 61,687 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,913 96,357 7,819 71,110 23,203 198,088 u 9,849 71,942 9,092 73,500 | | Minibus Diesel 1 2,078,312 7 375,456 66 553,744 44 463,161 5 546,993 5 546,926 5 74,4616 1,0 374,811 7 191,970 1,4 408,872 44 | | Small truck Diesel 183,267 60,848 59,125 67,714 84,232 68,031 40,207 69,882 | Truck Diesel 326,902 103,026 99,240 143,309 133,339 | Motorcycle Gasoline 24,795 49,654 165,723 23,844 30,969 11,829 80,610 47,019 |
|---|-------------|---|---|--|---|--|
| Gasoline Diesel 19,402 231,893 9,452 86,765 14,838 109,335 12,903 109,930 10,724 92,970 11,397 106,622 13,079 111,332 46,444 516,627 11,165 95,069 23,357 166,838 10,195 63,200 11,686 61,687 12,090 79,037 12,090 79,037 7,819 71,110 23,203 198,088 u 9,849 71,942 9,092 73,500 | | | 33,700 39,897 99,897 55,522 75,607 19,868 15,481 195,847 23,064 | Diesel 183,267 60,848 59,125 67,714 84,232 68,031 40,207 | Diesel 326,902 103,026 99,240 143,309 | Gasoline 24,795 49,654 165,723 23,844 30,969 11,829 80,610 47,019 |
| 19,402 231,893 9,452 86,765 14,838 109,335 12,903 109,930 10,724 92,970 11,397 106,622 13,079 111,332 14,44 516,627 11,165 95,069 23,357 166,838 10,195 63,200 11,686 61,687 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 13,819 71,110 23,203 198,088 u 9,849 71,942 | | | 33,700 99,897 55,522 75,607 19,868 15,481 15,481 15,481 11,690 | 183,267 60,848 59,125 67,714 84,232 68,031 40,207 69,882 | 326,902 103,026 99,240 143,309 | 24,795 49,654 165,723 23,844 30,969 11,829 80,610 47,019 |
| 9,452 86,765 14,838 109,335 12,903 109,930 10,724 92,970 11,397 106,622 13,079 111,332 46,444 516,627 11,165 95,069 23,357 166,838 10,195 63,200 11,686 61,687 12,090 79,037 12,090 79,037 12,090 79,037 1,819 71,110 23,203 198,088 u 9,849 71,942 | - | | 99,897 55,522 75,607 19,868 15,481 15,481 15,481 17,480 | 60,848 59,125 67,714 84,232 68,031 40,207 69,882 | 103,026 99,240 143,309 133,339 | 49,654 165,723 23,844 30,969 11,829 80,610 47,019 169,275 |
| 14,838 109,335 12,903 109,930 10,724 92,970 11,397 106,622 13,079 111,332 46,444 516,627 11,165 95,069 23,357 166,838 10,195 63,200 11,686 61,687 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 1,819 71,110 23,203 198,088 u 9,849 71,942 | _ | | 75,607 75,607 19,868 15,481 15,481 23,064 771,690 | 59,125 67,714 84,232 68,031 40,207 69,882 | 99,240 143,309 133,339 | 165,723 23,844 30,969 11,829 80,610 47,019 169,275 |
| 12,903 109,930 10,724 92,970 11,397 106,622 13,079 111,332 46,444 516,627 11,165 95,069 23,357 166,838 10,195 63,200 11,686 61,687 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 | | | 75,607 19,868 15,481 95,847 23,064 171,690 | 67,714 84,232 68,031 40,207 69,882 | 143,309 | 23,844 30,969 11,829 80,610 47,019 169,275 |
| 10,724 92,970 11,397 106,622 13,079 111,332 e 11,925 159,295 46,444 516,627 11,165 95,069 23,357 166,838 10,195 63,200 11,686 61,687 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 12,090 79,037 1,819 71,110 23,203 198,088 u 9,849 71,942 | | | 19,868 15,481 95,847 23,064 171,690 | 84,232 68,031 40,207 69,882 | 133,339 | 30,969 11,829 80,610 47,019 169,275 |
| ne 11,397 106,622 13,079 111,332 46,444 516,627 11,165 95,069 23,357 166,838 10,195 63,200 11,686 61,687 12,090 79,037 12,090 79,037 7,819 71,110 23,203 198,088 u 9,849 71,942 | | | 15,481 995,847 23,064 171,690 | 68,031 40,207 69,882 | 1 | 11,829 80,610 47,019 169,275 |
| ne 11,925 159,295 46,444 516,627 11,165 95,069 23,357 166,838 10,195 63,200 11,686 61,687 12,090 79,037 12,090 79,037 7,819 71,110 23,203 198,088 u 9,849 71,942 | | | 995,847 23,064 171,690 | 40,207 69,882 | 118,457 | 80,610 47,019 169,275 |
| ne 11,925 159,295 46,444 516,627 11,165 95,069 23,357 166,838 10,195 63,200 11,686 61,687 12,090 79,037 12,090 79,037 7,819 71,110 23,203 198,088 u 9,849 71,942 | | | 23,064 | 69,882 | 806,68 | 47,019 169,275 |
| 46,444 516,627 11,165 95,069 23,357 166,838 10,195 63,200 11,686 61,687 12,090 79,037 12,090 79,037 9,413 96,357 7,819 71,110 23,203 198,088 u 9,849 71,942 9,092 73,500 | | | 171,690 | 0,00 | 101,765 | 169,275 |
| 11,165 95,069 23,357 166,838 10,195 63,200 11,686 61,687 12,090 79,037 8,922 71,708 9,413 96,357 7,819 71,110 23,203 198,088 u 9,849 71,942 | | | | 112,369 | 71,026 | |
| 10,195 166,838 10,195 63,200 11,686 61,687 12,090 79,037 8,922 71,708 9,413 96,357 7,819 71,110 23,203 198,088 u 9,849 71,942 | | | 464,147 | 77,564 | 88,787 | 8,110 |
| 10,195 63,200 11,686 61,687 12,090 79,037 8,922 71,708 9,413 96,357 7,819 71,110 23,203 198,088 u 9,849 71,942 | | 33,276 | 321,160 | 48,021 | 30,476 | 12,775 |
| 11,686 61,687 12,090 79,037 12,090 79,037 9,413 96,357 7,819 71,110 23,203 198,088 u 9,849 71,942 | 16,089 51 | 515,025 | 310,731 | 50,576 | 100,798 | 11,582 |
| 12,090 79,037 8,922 71,708 9,413 96,357 7,819 71,110 23,203 198,088 u 9,849 71,942 | 4,972 46 | 462,734 3' | 375,558 | 65,524 | 117,605 | 57,600 |
| umaraş 8,922 71,708 9,413 96,357 7,819 71,110 23,203 198,088 u 9,849 71,942 9,092 73,500 | 14,074 95 | 954,712 34 | 346,310 | 64,618 | 130,526 | 19,111 |
| 9,413 96,357 7,819 71,110 23,203 198,088 u 9,849 71,942 9,092 73,500 | 26,712 31 | 317,671 40 | 406,190 | 54,858 | 111,346 | 30,168 |
| 7,819 71,110 23,203 198,088 u 9,849 71,942 9,092 73,500 | 17,152 56 | 565,925 50 | 561,453 | 101,208 | 118,484 | 51,153 |
| 23,203 198,088 u 9,849 71,942 9,092 73,500 | 18,332 34 | 345,707 36 | 366,426 | 53,245 | 93,400 | 5,952 |
| u 9,849 71,942 9,092 73,500 | 24,490 33 | 334,171 5: | 552,785 | 72,893 | 112,012 | 94,533 |
| 9,092 73,500 | 20,060 39 | 390,738 | 359,067 | 62,838 | 76,206 | 31,850 |
| | 17,553 67 | 676,050 | 318,007 | 66,845 | 92,964 | 64,876 |
| Kırıkkale 10,153 217,143 33,494 | 33,494 1,30 | 1,365,430 1,2 | 1,248,898 | 268,586 | 320,774 | 59,430 |
| Kırklareli 16,965 105,203 11,458 | 11,458 77 | 3. | 378,805 | 94,095 | 133,628 | 20,428 |
| Kırşehir 8,048 57,459 19,555 | 19,555 49 | 491,543 3 | 341,477 | 63,258 | 85,663 | 36,713 |
| Kilis 22,007 83,533 26,897 | 26,897 21 | 217,796 50 | 508,141 | 58,064 | 75,630 | 5,566 |
| Kocaeli 17,514 162,351 17,921 | 17,921 1,08 | ,088,059 4 | 476,348 | 124,926 | 146,626 | 75,718 |
| Konya 8,690 110,315 19,359 | 19,359 86 | 867,324 59 | 598,891 | 78,691 | 96,439 | 15,538 |
| Kütahya 8,331 88,279 17,500 | 17,500 58 | 585,340 4. | 437,692 | 85,479 | 118,574 | 15,762 |

Table 4 Average annual range of vehicles (km) (continued)

| Car Minibus Bus SS Gasoline Diesel Diesel Diesel Diesel Diesel S49,318 10,063 71,173 17,769 347,750 349,318 349,318 349,318 11,685 97,362 21,028 717,142 259,462 137,856 137,856 137,856 137,856 137,856 137,856 137,856 137,856 137,856 137,856 137,856 137,856 14,074 14,056 14,074 14,060,152 252,043 252,443 | | | | | | 2018 | | | |
|--|-----------|----------|---------|--------|-----------|-----------|-------------|---------|------------|
| Gasoline Diesel LPG Diesel Diesel 10,063 71,173 17,769 347,750 349,318 11,685 97,362 21,028 717,142 259,462 19,672 252,082 35,502 323,012 737,856 11,614 204,724 18,191 1,568,922 918,325 19,100 83,240 16,615 430,412 346,052 19,100 83,240 16,615 430,412 346,052 10,100 83,240 16,615 430,412 346,052 11,732 20,378 680,349 1,060,152 9,009 177,728 20,378 680,349 1,060,152 12,548 87,822 22,793 143,716 562,565 13,031 96,447 24,238 608,349 1,060,152 10,526 119,385 18,233 369,381 1,627,168 10,526 97,447 17,831 569,389 1,627,168 10,366 96,487 88,697 | Provinces | | Car | | Minibus | Bus | Small truck | Truck | Motorcycle |
| 10,063 71,173 17,769 347,750 349,318 11,685 97,362 21,028 717,142 259,462 19,672 252,082 35,502 323,012 737,856 11,614 204,724 18,191 1,568,922 918,325 19,100 83,240 1,6615 430,412 346,052 19,100 83,240 1,6615 31,1755 929,431 9,009 177,728 20,378 680,349 1,060,152 9,216 119,843 20,338 692,746 536,408 12,548 87,822 22,793 143,716 562,565 14,074 116,036 21,106 326,311 447,616 14,074 116,036 21,106 326,311 447,616 16,526 21,106 326,311 447,616 562,656 19,142 321,807 24,338 56,467 56,478 56,478 10,396 65,661 20,813 36,532 52,431 56,489 | 1 | Gasoline | Diesel | TBG | Diesel | Diesel | Diesel | Diesel | Gasoline |
| 11,685 97,362 21,028 717,142 259,462 19,672 252,082 35,502 323,012 737,856 11,614 204,724 18,191 1,568,922 918,325 19,100 83,240 1,6615 430,412 346,052 19,100 83,240 1,6615 430,412 346,052 9,009 177,728 20,378 680,349 1,060,152 9,216 119,843 20,338 692,746 536,408 12,548 87,822 22,793 143,716 562,565 1,4074 116,036 21,106 326,311 447,616 1,4074 116,036 18,028 524,48 562,565 1,938 16,447 24,238 665,831 1,194,960 1,039 65,661 20,813 369,581 51,496 1,039 65,661 20,813 369,581 51,496 1,039 11,1183 39,922 28,390 62,482 1,056 15,697 | Malatya | 10,063 | 71,173 | 17,769 | 347,750 | 349,318 | 47,462 | 113,193 | 49,738 |
| 19,672 252,082 35,502 737,856 11,614 204,724 18,191 1,568,922 918,325 19,100 83,240 16,615 430,412 918,325 9,009 177,728 20,378 680,349 1,060,152 9,216 119,843 20,389 692,746 556,408 12,548 87,822 22,793 143,716 562,565 1,589 66,156 21,106 326,311 447,616 14,074 116,036 18,028 581,032 562,565 1,589 66,156 21,106 326,311 447,616 1,0,301 96,447 24,238 605,93 338,014 10,526 119,385 18,233 369,581 1,194,960 10,396 65,661 20,813 326,322 358,014 10,396 117,183 39,222 38,309 1,194,960 11,386 11,381 39,528 35,481 1,296,087 11,386 15,697 10,389,99 | Manisa | 11,685 | 97,362 | 21,028 | 717,142 | 259,462 | 73,178 | 121,386 | 7,496 |
| 11,614 204,724 18,191 1,568,922 918,325 19,100 83,240 16,615 430,412 346,052 17,752 218,832 46,360 311,755 929,431 9,009 177,728 20,378 680,349 1,060,152 12,548 87,822 22,793 143,716 562,565 7,589 66,156 21,106 326,311 447,616 14,074 116,036 18,028 281,478 541,032 13,031 96,447 24,238 605,993 358,014 10,526 119,385 18,233 369,581 1,194,960 10,436 56,447 24,238 605,993 358,014 10,536 65,661 20,813 250,322 552,431 9,652 97,447 17,831 395,580 552,431 10,396 65,661 20,813 250,322 28,326 13,561 117,183 39,922 288,300 698,134 16,623 16,537 16,637 16,638 34,572 560,72 580,469 <th< th=""><th>Mardin</th><th>19,672</th><th>252,082</th><th>35,502</th><th>323,012</th><th>737,856</th><th>75,304</th><th>51,468</th><th>34,644</th></th<> | Mardin | 19,672 | 252,082 | 35,502 | 323,012 | 737,856 | 75,304 | 51,468 | 34,644 |
| 19,100 83,240 16,615 430,412 346,052 17,752 218,832 46,360 311,755 929,431 9,009 177,728 20,378 680,349 1,060,152 9,216 119,843 20,389 692,746 562,565 1,589 66,156 21,106 326,311 447,616 1,4074 116,036 18,028 281,478 562,565 1,0,526 119,385 18,233 38,014 447,616 1,0,526 119,385 18,233 36,581 1,104,960 16,57,168 10,526 119,385 18,233 36,581 1,104,960 16,57,168 10,526 119,385 18,233 36,581 1,104,960 16,57,168 10,526 97,447 17,831 565,280 582,431 16,57,168 10,536 964,874 58,920 627,825 1,580,087 1,580,087 10,623 10,438 15,697 1,038,994 378,333 1,580,087 10,623 | Mersin | 11,614 | 204,724 | 18,191 | 1,568,922 | 918,325 | 131,672 | 157,978 | 11,483 |
| 17,752 218,832 46,360 311,755 99,431 9,009 177,728 20,378 680,349 1,060,152 9,216 119,843 20,389 692,746 536,408 12,548 87,822 22,793 143,716 562,565 7,589 66,156 21,106 326,311 447,616 14,074 116,036 18,028 581,032 561,032 10,526 119,385 18,233 366,581 1,194,960 10,540 24,238 66,593 38,614 1,194,960 10,436 18,233 369,581 1,194,960 1,194,960 10,436 18,233 369,581 1,194,960 1,117,183 39,922 28,328 1,27,168 10,436 17,487 17,831 250,322 1,95,008 1,98,134 1,038,994 378,333 1,38,138 1,038,994 378,333 1,038,994 1,96,008 1,96,472 1,038,994 1,96,472 1,038,994 1,96,472 1,96,472 1,96,472 1,96,47 | Muğla | 19,100 | 83,240 | 16,615 | 430,412 | 346,052 | 58,798 | 164,345 | 13,233 |
| 9,009177,72820,378680,3491,060,1529,216119,84320,389692,746536,40812,54887,82222,793143,716562,56514,074116,03618,028281,478541,03213,03196,44724,238605,993358,01410,526119,38518,233369,5811,194,96019,142321,80733,677332,1931,627,16810,39665,66120,813250,322552,4319,65297,44717,831595,580533,28613,961117,18339,922288,300698,134117,389155,07815,6971,038,994378,3338,62483,13817,803385,751465,47210,623106,43613,874266,072580,46921,056196,35834,572264,679600,91616,38492,45712,837399,917299,5898,355105,26928,203491,488787,203 | Muş | 17,752 | 218,832 | 46,360 | 311,755 | 929,431 | 62,818 | 99,174 | 96,050 |
| 9,216119,84320,389692,746536,40812,54887,82222,793143,716562,5657,58966,15621,106326,311447,61614,074116,03618,028281,478541,03219,02196,44724,238605,993358,01410,526119,38518,233369,5811,194,96019,142321,80733,677332,1931,627,16810,39665,66120,813250,322552,4319,65297,44717,831595,580533,28613,961117,18339,922288,300698,134117,389155,07815,6971,038,994378,3338,62483,13817,803385,751465,47210,623106,43613,874266,072580,46921,056196,35834,572264,679631,4699,21958,10216,865427,150299,58916,38492,45712,837399,917299,5898,355105,26928,203491,488787,203 | Nevşehir | 600,6 | 177,728 | 20,378 | 680,349 | 1,060,152 | 120,648 | 122,661 | 16,695 |
| 12,548 87,822 22,793 143,716 562,565 7,589 66,156 21,106 326,311 447,616 14,074 116,036 18,028 281,478 541,032 13,031 96,447 24,238 605,993 358,014 10,526 119,385 18,233 369,581 1,194,960 10,402 31,807 33,677 332,193 1,627,168 10,396 65,661 20,813 552,431 562,431 9,652 97,447 17,831 595,890 533,286 13,961 117,183 39,922 288,300 698,134 17,389 155,078 15,897 1,950,087 17,389 155,078 15,897 1,038,994 378,333 8,624 83,138 17,803 385,751 465,472 10,623 102,472 13,874 266,072 580,469 9,219 58,102 16,865 427,150 591,469 16,384 92,457 138,477 | Niğde | 9,216 | 119,843 | 20,389 | 692,746 | 536,408 | 76,317 | 86,403 | 15,296 |
| 7,589 66,156 21,106 326,311 447,616 14,074 116,036 18,028 281,478 541,032 13,031 96,447 24,238 605,993 358,014 10,526 119,385 18,233 369,581 1,194,960 10,396 65,661 20,813 250,322 552,431 9,652 97,447 17,831 595,580 552,431 30,263 96,4874 58,920 627,825 1,950,087 17,389 155,078 15,697 1,038,994 378,333 8,624 83,138 17,803 385,751 465,472 10,623 102,472 13,874 266,072 580,469 9,219 58,102 16,865 427,150 600,916 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 600,916 600,916 | Ordu | 12,548 | 87,822 | 22,793 | 143,716 | 562,565 | 44,394 | 97,529 | 80,407 |
| 14,074 116,036 18,028 281,478 541,032 13,031 96,447 24,238 605,993 358,014 10,526 119,385 18,233 369,581 1,194,960 19,142 321,807 33,677 332,193 1,627,168 10,396 65,661 20,813 250,322 552,431 9,652 97,447 17,831 595,880 633,286 13,961 117,183 39,922 288,300 698,134 17,389 155,078 15,697 1,038,994 378,333 8,624 83,138 17,803 385,751 465,472 10,623 106,388 17,803 385,751 465,472 9,219 58,102 16,865 254,679 683,282 9,219 58,102 16,865 427,150 291,469 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Osmaniye | 7,589 | 66,156 | 21,106 | 326,311 | 447,616 | 56,349 | 129,726 | 9,475 |
| 13,031 96,447 24,238 605,993 358,014 10,526 119,385 18,233 369,581 1,194,960 19,142 321,807 332,193 1,627,168 10,396 65,661 20,813 250,322 552,431 9,652 97,447 17,831 595,580 533,286 13,961 117,183 39,922 288,300 698,134 30,263 964,874 58,920 627,825 1,950,087 17,389 155,078 15,697 1,038,994 378,333 8,624 83,138 17,803 385,751 465,472 10,623 102,472 13,874 266,072 580,469 9,219 58,102 16,865 427,150 631,469 9,219 58,102 16,865 427,150 291,689 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Rize | 14,074 | 116,036 | 18,028 | 281,478 | 541,032 | 29,984 | 60,330 | 92,099 |
| 10,526 119,385 18,233 369,581 1,194,960 19,142 321,807 33,677 332,193 1,627,168 10,396 65,661 20,813 250,322 552,431 9,652 97,447 17,831 595,580 533,286 13,961 117,183 39,922 288,300 698,134 30,263 964,874 58,920 627,825 1,950,087 17,389 155,078 15,697 1,038,994 378,333 8,624 83,138 17,803 385,751 465,472 10,623 102,472 13,874 266,072 580,469 21,056 196,358 34,572 264,679 683,282 9,219 58,102 16,865 427,150 291,469 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Sakarya | 13,031 | 96,447 | 24,238 | 605,993 | 358,014 | 73,177 | 117,021 | 32,704 |
| 19,142 321,807 33,677 332,193 1,627,168 10,396 65,661 20,813 250,322 552,431 9,652 97,447 17,831 595,580 533,286 13,961 117,183 39,922 288,300 698,134 30,263 964,874 58,920 627,825 1,950,087 17,389 155,078 15,697 1,038,994 378,333 8,624 83,138 17,803 385,751 465,472 10,623 106,38 34,572 266,072 580,469 21,056 196,358 34,572 266,072 831,469 23,138 154,241 38,667 138,157 600,916 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Samsun | 10,526 | 119,385 | 18,233 | 369,581 | 1,194,960 | 74,182 | 180,287 | 25,846 |
| 10,366 65,661 20,813 552,431 9,652 97,447 17,831 595,580 533,286 13,961 117,183 39,922 288,300 698,134 30,263 964,874 58,920 627,825 1,950,087 17,389 155,078 15,697 1,038,994 378,333 8,624 83,138 17,803 385,751 465,472 10,623 102,472 13,874 266,072 580,469 21,056 196,358 34,572 254,679 683,282 9,219 58,102 16,865 427,150 231,469 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Siirt | 19,142 | 321,807 | 33,677 | 332,193 | 1,627,168 | 102,797 | 180,956 | 40,280 |
| 9,65297,44717,831595,580533,28613,961117,18339,922288,300698,13430,263964,87458,920627,8251,950,08717,389155,07815,6971,038,994378,3338,62483,13817,803385,751465,47210,623102,47213,874266,072580,46921,056196,35834,572254,679683,2829,21958,10216,865427,150231,46916,38492,45712,837399,917299,5898,355105,26928,203491,488787,203 | Sinop | 10,396 | 65,661 | 20,813 | 250,322 | 552,431 | 56,231 | 89,750 | 31,142 |
| 13,961 117,183 39,922 288,300 698,134 30,263 964,874 58,920 627,825 1,950,087 17,389 155,078 15,697 1,038,994 378,333 8,624 83,138 17,803 385,751 465,472 10,623 102,472 13,874 266,072 580,469 21,056 196,358 34,572 254,679 683,282 9,219 58,102 16,865 427,150 231,469 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Sivas | 9,652 | 97,447 | 17,831 | 595,580 | 533,286 | 77,341 | 118,297 | 59,505 |
| 30,263 964,874 58,920 627,825 1,950,087 17,389 155,078 15,697 1,038,994 378,333 8,624 83,138 17,803 385,751 465,472 10,623 102,472 13,874 266,072 580,469 21,056 196,358 34,572 254,679 683,282 9,219 58,102 16,865 427,150 231,469 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Şanlıurfa | 13,961 | 117,183 | 39,922 | 288,300 | 698,134 | 89,117 | 889,69 | 10,604 |
| 17,389 155,078 15,697 1,038,994 378,333 8,624 83,138 17,803 385,751 465,472 10,623 102,472 13,874 266,072 580,469 21,056 196,358 34,572 254,679 683,282 9,219 58,102 16,865 427,150 231,469 23,138 154,241 38,667 138,157 600,916 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Şırnak | 30,263 | 964,874 | 58,920 | 627,825 | 1,950,087 | 173,645 | 33,210 | 28,005 |
| 8,624 83,138 17,803 385,751 465,472 10,623 102,472 13,874 266,072 580,469 21,056 196,358 34,572 254,679 683,282 9,219 58,102 16,865 427,150 231,469 23,138 154,241 38,667 138,157 600,916 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Tekirdağ | 17,389 | 155,078 | 15,697 | 1,038,994 | 378,333 | 122,681 | 189,220 | 45,553 |
| 10,623 102,472 13,874 266,072 580,469 21,056 196,358 34,572 254,679 683,282 9,219 58,102 16,865 427,150 231,469 23,138 154,241 38,667 138,157 600,916 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Tokat | 8,624 | 83,138 | 17,803 | 385,751 | 465,472 | 63,396 | 130,800 | 19,820 |
| 21,056 196,358 34,572 254,679 683,282 9,219 58,102 16,865 427,150 231,469 23,138 154,241 38,667 138,157 600,916 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Trabzon | 10,623 | 102,472 | 13,874 | 266,072 | 580,469 | 46,503 | 83,387 | 90,633 |
| 9,219 58,102 16,865 427,150 231,469 23,138 154,241 38,667 138,157 600,916 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Tunceli | 21,056 | 196,358 | 34,572 | 254,679 | 683,282 | 92,675 | 132,488 | 70,338 |
| 23,138 154,241 38,667 138,157 600,916 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Uşak | 9,219 | 58,102 | 16,865 | 427,150 | 231,469 | 50,642 | 85,364 | 13,836 |
| 16,384 92,457 12,837 399,917 299,589 8,355 105,269 28,203 491,488 787,203 | Van | 23,138 | 154,241 | 38,667 | 138,157 | 600,916 | 44,513 | 60,852 | 115,098 |
| 8,355 105,269 28,203 491,488 787,203 | Yalova | 16,384 | 92,457 | 12,837 | 399,917 | 299,589 | 61,950 | 143,625 | 41,740 |
| | Yozgat | 8,355 | 105,269 | 28,203 | 491,488 | 787,203 | 99,981 | 88,615 | 64,259 |
| | Zonguldak | 9,281 | 47,074 | 16,067 | 245,143 | 211,957 | 42,019 | 64,701 | 43,073 |

 Table 4
 Average annual range of vehicles (km) (continued)

| | | | | | 2020 | | | |
|----------------|----------|-----------|--------|-----------|-----------|-------------|---------|------------|
| Provinces | | Car | | Minibus | Bus | Small truck | Truck | Motorcycle |
| | Gasoline | Diesel | DAT | Diesel | Diesel | Diesel | Diesel | Gasoline |
| Adana | 9,628 | 865'69 | 16,487 | 549,955 | 489,239 | 59,064 | 113,534 | 12,547 |
| Adıyaman | 9,626 | 82,607 | 28,575 | 243,012 | 1,017,653 | 69,492 | 115,328 | 16,600 |
| Afyonkarahisar | 14,313 | 139,287 | 26,472 | 651,335 | 767,100 | 860'68 | 120,050 | 16,078 |
| Ağn | 30,640 | 367,659 | 55,861 | 360,548 | 1,055,175 | 119,454 | 149,618 | 92,976 |
| Aksaray | 9,727 | 93,211 | 18,473 | 1,102,320 | 429,573 | 87,543 | 90,766 | 24,525 |
| Amasya | 8,192 | 66,904 | 20,361 | 358,174 | 582,733 | 59,337 | 107,145 | 19,145 |
| Ankara | 7,850 | 55,151 | 9,901 | 852,688 | 443,339 | 70,219 | 98,059 | 111,956 |
| Antalya | 11,040 | 50,944 | 12,066 | 443,135 | 237,171 | 36,669 | 105,934 | 10,467 |
| Ardahan | 31,454 | 1,252,403 | 38,427 | 1,688,995 | 8,232,410 | 431,971 | 909,101 | 118,826 |
| Artvin | 17,539 | 151,873 | 17,590 | 312,002 | 734,235 | 45,701 | 64,756 | 85,176 |
| Aydın | 14,076 | 124,364 | 16,483 | 570,226 | 760,269 | 83,149 | 241,972 | 9,835 |
| Balıkesir | 15,568 | 83,002 | 15,271 | 717,676 | 539,675 | 65,891 | 132,585 | 14,138 |
| Bartın | 11,406 | 50,128 | 18,868 | 250,368 | 267,020 | 49,062 | 85,892 | 32,721 |
| Batman | 23,020 | 468,721 | 32,353 | 684,124 | 2,358,326 | 161,559 | 262,138 | 25,853 |
| Bayburt | 13,696 | 106,427 | 19,970 | 321,510 | 607,149 | 63,030 | 99,400 | 38,108 |
| Bilecik | 12,769 | 96,207 | 15,120 | 767,877 | 353,526 | 69,161 | 97,075 | 28,430 |
| Bingöl | 23,724 | 180,317 | 36,349 | 306,397 | 555,725 | 80,722 | 116,515 | 138,367 |
| Bitlis | 24,977 | 328,734 | 49,967 | 426,357 | 1,510,289 | 110,896 | 137,299 | 162,388 |
| Bolu | 18,607 | 101,239 | 19,602 | 984,558 | 585,261 | 87,576 | 90,592 | 46,072 |
| Burdur | 9,438 | 97,875 | 17,635 | 1,009,877 | 616,405 | 86,406 | 88,456 | 7,760 |
| Bursa | 13,085 | 66,567 | 9,183 | 586,361 | 411,412 | 51,623 | 115,004 | 32,348 |
| Çanakkale | 18,116 | 92,568 | 12,806 | 844,341 | 462,570 | 65,169 | 136,393 | 13,930 |
| Çankırı | 14,589 | 261,506 | 25,446 | 2,022,651 | 1,050,909 | 176,720 | 282,031 | 30,032 |
| Çorum | 9,431 | 91,597 | 20,975 | 729,030 | 673,944 | 86,077 | 124,327 | 22,169 |
| Denizli | 9,300 | 121,911 | 15,256 | 884,527 | 597,611 | 95,491 | 193,307 | 13,317 |
| Diyarbakır | 22,799 | 158,442 | 39,264 | 353,562 | 544,245 | 96,529 | 117,433 | 56,928 |
| Düzce | 14,335 | 81,532 | 21,258 | 453,831 | 287,225 | 68,228 | 94,479 | 24,150 |
| | | | | | | | | |

Table 4 Average annual range of vehicles (km) (continued)

| | | | | | 2020 | | | |
|---------------|----------|---------|--------|-----------|-----------|-------------|---------|------------|
| Provinces | | Car | | Minibus | Bus | Small truck | Truck | Motorcycle |
| • | Gasoline | Diesel | LPG | Diesel | Diesel | Diesel | Diesel | Gasoline |
| Edime | 18,238 | 324,034 | 12,005 | 2,977,874 | 1,191,138 | 262,824 | 477,194 | 22,182 |
| Elazığ | 10,041 | 69,936 | 15,847 | 356,422 | 628,064 | 51,595 | 88,592 | 51,272 |
| Erzurum | 15,092 | 98,587 | 18,758 | 571,676 | 463,563 | 56,498 | 95,813 | 150,588 |
| Erzincan | 13,945 | 690'86 | 17,805 | 460,181 | 554,813 | 63,490 | 135,696 | 24,320 |
| Eskişehir | 10,093 | 76,459 | 10,210 | 864,968 | 476,180 | 72,073 | 115,533 | 27,016 |
| Gaziantep | 10,885 | 105,005 | 16,302 | 481,658 | 525,214 | 68,451 | 120,040 | 10,926 |
| Giresun | 14,693 | 113,387 | 24,401 | 169,840 | 1,196,338 | 41,844 | 100,423 | 77,767 |
| Gümüşhane | 13,849 | 116,570 | 20,542 | 311,262 | 580,569 | 53,650 | 80,159 | 51,062 |
| Hakkari | 53,930 | 531,900 | 84,996 | 237,029 | 1,489,350 | 136,498 | 80,264 | 142,861 |
| Hatay | 11,023 | 84,557 | 16,487 | 448,697 | 455,147 | 74,423 | 86,548 | 7,945 |
| Iğdır | 27,212 | 190,768 | 26,860 | 229,595 | 419,732 | 56,553 | 34,636 | 13,394 |
| Isparta | 9,892 | 50,513 | 14,710 | 442,741 | 279,874 | 42,400 | 86,287 | 10,339 |
| İstanbul | 10,757 | 49,245 | 4,402 | 391,423 | 350,483 | 54,135 | 103,165 | 45,341 |
| İzmir | 11,415 | 59,591 | 11,543 | 736,516 | 303,300 | 51,127 | 106,288 | 17,466 |
| Kahramanmaraş | 9,366 | 60,874 | 25,126 | 309,535 | 395,447 | 48,967 | 103,366 | 31,423 |
| Karabük | 9,588 | 133,825 | 15,962 | 840,943 | 888,562 | 145,544 | 169,097 | 44,248 |
| Karaman | 8,431 | 69,759 | 18,073 | 382,249 | 421,662 | 53,220 | 94,796 | 6,285 |
| Kars | 23,818 | 178,254 | 24,366 | 336,687 | 541,514 | 71,213 | 110,275 | 84,070 |
| Kastamonu | 10,634 | 73,600 | 19,098 | 445,666 | 439,762 | 63,902 | 80,781 | 30,663 |
| Kayseri | 9,231 | 57,809 | 15,973 | 554,496 | 255,260 | 54,346 | 77,567 | 60,811 |
| Kırıkkale | 11,362 | 166,284 | 31,853 | 1,041,253 | 1,131,449 | 209,605 | 246,775 | 57,353 |
| Kırklareli | 17,192 | 105,867 | 11,623 | 726,760 | 368,542 | 99,691 | 142,041 | 19,437 |
| Kırşehir | 8,627 | 55,783 | 19,347 | 503,923 | 409,774 | 63,110 | 85,419 | 35,779 |
| Kilis | 22,129 | 89,369 | 27,099 | 273,691 | 650,607 | 65,610 | 88,887 | 5,291 |
| Kocaeli | 16,609 | 125,438 | 15,972 | 860,606 | 417,270 | 103,776 | 124,996 | 65,324 |
| Konya | 8,663 | 84,757 | 17,724 | 675,839 | 502,731 | 61,787 | 75,315 | 15,106 |
| Kütahya | 8,514 | 95,227 | 16,295 | 687,801 | 529,164 | 95,370 | 132,657 | 14,668 |
| | | | | | | | | |

 Table 4
 Average annual range of vehicles (km) (continued)

| | | | | | 2020 | | | |
|-----------|----------|-----------|--------|-----------|-----------|-------------|-----------|------------|
| Provinces | | Car | | Minibus | Bus | Small truck | Truck | Motorcycle |
| | Gasoline | Diesel | DAT | Diesel | Diesel | Diesel | Diesel | Gasoline |
| Malatya | 10,473 | 58,046 | 17,026 | 323,942 | 301,005 | 40,933 | 80,708 | 48,776 |
| Manisa | 13,119 | 94,347 | 19,875 | 722,969 | 277,558 | 72,411 | 125,187 | 8,021 |
| Mardin | 20,784 | 320,403 | 34,246 | 450,256 | 1,009,449 | 104,621 | 69,176 | 30,637 |
| Mersin | 2,738 | 131,662 | 17,386 | 6,479,378 | 6,910,342 | 1,269,703 | 2,222,848 | 317,208 |
| Muğla | 19,358 | 68,200 | 15,605 | 395,778 | 317,786 | 49,269 | 139,412 | 12,639 |
| Muş | 20,556 | 210,391 | 47,157 | 330,645 | 856,752 | 64,885 | 101,971 | 97,415 |
| Nevşehir | 9,061 | 81,767 | 16,606 | 314,433 | 545,839 | 56,887 | 61,200 | 16,395 |
| Niğde | 9,846 | 109,940 | 19,950 | 675,932 | 538,989 | 72,440 | 85,863 | 16,269 |
| Ordu | 13,947 | 80,724 | 21,402 | 148,605 | 526,507 | 43,582 | 691,76 | 77,031 |
| Osmaniye | 7,732 | 45,227 | 20,808 | 252,983 | 338,791 | 40,665 | 94,990 | 6,589 |
| Rize | 14,637 | 105,249 | 16,695 | 284,471 | 605,530 | 28,501 | 60,151 | 84,556 |
| Sakarya | 13,199 | 83,391 | 22,005 | 559,295 | 372,642 | 66,314 | 109,282 | 30,311 |
| Samsun | 10,496 | 97,910 | 16,191 | 348,373 | 1,128,415 | 65,056 | 163,654 | 25,476 |
| Siirt | 20,917 | 367,726 | 42,749 | 412,085 | 1,845,623 | 123,506 | 239,741 | 35,884 |
| Sinop | 11,275 | 56,230 | 18,430 | 240,778 | 540,156 | 50,010 | 81,062 | 28,633 |
| Sivas | 9,749 | 72,936 | 17,282 | 509,316 | 469,568 | 60,675 | 95,509 | 55,403 |
| Şanlıurfa | 15,077 | 128,172 | 44,680 | 338,721 | 731,868 | 105,663 | 77,502 | 10,239 |
| Şırnak | 35,775 | 1,064,667 | 62,865 | 896,499 | 2,493,052 | 250,038 | 44,627 | 32,227 |
| Tekirdağ | 17,470 | 165,714 | 15,443 | 1,169,440 | 423,000 | 136,836 | 209,041 | 42,165 |
| Tokat | 9,266 | 76,876 | 16,947 | 408,358 | 525,262 | 62,096 | 133,466 | 20,784 |
| Trabzon | 10,514 | 76,617 | 12,207 | 225,764 | 548,516 | 37,002 | 71,189 | 81,287 |
| Tunceli | 22,979 | 154,341 | 32,001 | 256,985 | 537,744 | 79,778 | 120,570 | 74,862 |
| Uşak | 9,130 | 66,124 | 16,321 | 491,408 | 309,427 | 58,686 | 101,603 | 12,694 |
| Van | 23,820 | 134,883 | 38,514 | 129,893 | 492,588 | 42,302 | 57,401 | 97,971 |
| Yalova | 18,504 | 88,700 | 12,004 | 381,596 | 307,822 | 62,643 | 148,783 | 38,991 |
| Yozgat | 9,383 | 111,850 | 28,033 | 596,304 | 908,702 | 107,322 | 97,818 | 62,761 |
| Zonguldak | 9,470 | 52,044 | 14,821 | 297,325 | 264,884 | 49,887 | 75,398 | 37,103 |
| | | | | | | | | |

Table 5Fuel densities

| Fuel | Density at 15°C, kg/L | Density accepted in the study, kg/L |
|----------|-----------------------|-------------------------------------|
| Gasoline | 0.730-0.780 | 0.760 |
| Diesel | 0.810-0.850 | 0.830 |
| LPG | 0.508-0.584 | 0.550 |

Source: Bayrakçeken and Kuş (2004)

2.2.3 Tier-3 approach

For energy, the tier-3 method uses either detailed emission models or individual plant-level measurements and data where appropriate. When properly applied, these models and measurements provide better estimates primarily of non-CO₂ greenhouse gases, although at the expense of more detailed information and effort (IPCC, 2006). Since the necessary data for the tier-3 method could not be obtained, calculations could not be made according to the tier-3 method in this study.

3 Results

Within the scope of this study, carbon footprint calculations originating from road transportation in Turkey for 2018 and 2020 were calculated using Tier 1 and Tier 2 methods for each province and presented with maps prepared using the ARCGIS method.

3.1 Carbon footprint by tier-1 method

CO₂ emissions calculated according to the tier-1 method for all provinces are presented in Table 6. Looking at Table 6, it is seen that diesel fuels have the highest CO₂ emissions and gasoline has the lowest CO₂ emissions among the fuels consumed in Turkey. As can be seen in Table 2, this is the result of the fact that diesel fuel is preferred the most throughout the country. In Figure 2, the CO₂ emissions generated by the fuel consumed for 2018 and 2020, respectively, are presented. In the calculations made according to the Tier 1 method, it is seen in Figure 2 that the CO₂ emissions from gasoline are 7.4% and 7.7%, the CO₂ emissions from diesel fuel are 79.8% and 79.9%, and the CO₂ emissions from LPG are 12.8% and 12.4%, for 2018 and 2020 respectively. Figure 2 shows that there is no significant difference between 2018 and 2020 in the CO₂ emission values. According to the tier-1 method, it is seen in Figures 3 and 4 and Table 6 that Istanbul, Ankara and Izmir have the highest CO₂ emissions in Turkey respectively for 2018 and 2020, followed by the big cities. Again, when Figures 3 and 4 are examined, it is seen that western provinces have higher CO2 emissions than eastern provinces. It is thought that CO₂ emissions are high as a result of the higher population density of the western provinces.

 Table 6
 CO₂ emissions of provinces according to tier-1 method

| n · | | 2018 | | | 2020 | |
|----------------|----------|--------|-------|----------|--------|-------|
| Provinces | Gasoline | Diesel | LPG | Gasoline | Diesel | LPG |
| Adana | 157 | 1,718 | 395 | 161 | 1,776 | 384 |
| Adıyaman | 22 | 396 | 107 | 24 | 312 | 99 |
| Afyonkarahisar | 57 | 747 | 169 | 62 | 924 | 160 |
| Ağrı | 12 | 236 | 35 | 13 | 236 | 33 |
| Aksaray | 27 | 433 | 87 | 32 | 463 | 84 |
| Amasya | 23 | 307 | 82 | 24 | 301 | 84 |
| Ankara | 626 | 6,512 | 1,186 | 596 | 6,398 | 1,048 |
| Antalya | 298 | 2,277 | 463 | 292 | 2,060 | 445 |
| Ardahan | 5 | 72 | 8 | 6 | 348 | 10 |
| Artvin | 13 | 174 | 20 | 14 | 187 | 20 |
| Aydın | 125 | 951 | 226 | 128 | 1,722 | 208 |
| Balıkesir | 152 | 1,308 | 232 | 163 | 1,326 | 223 |
| Bartın | 16 | 124 | 40 | 16 | 109 | 38 |
| Batman | 18 | 323 | 37 | 17 | 526 | 33 |
| Bayburt | 4 | 56 | 9 | 4 | 53 | 9 |
| Bilecik | 20 | 255 | 35 | 21 | 241 | 35 |
| Bingöl | 8 | 110 | 23 | 9 | 106 | 19 |
| Bitlis | 9 | 166 | 28 | 9 | 188 | 26 |
| Bolu | 46 | 478 | 82 | 51 | 428 | 76 |
| Burdur | 25 | 489 | 73 | 25 | 398 | 66 |
| Bursa | 329 | 2,700 | 350 | 336 | 2,611 | 329 |
| Çanakkale | 81 | 586 | 91 | 82 | 644 | 81 |
| Çankırı | 13 | 227 | 41 | 15 | 423 | 38 |
| Çorum | 33 | 473 | 126 | 38 | 559 | 117 |
| Denizli | 93 | 1,386 | 227 | 92 | 1,840 | 210 |
| Diyarbakır | 55 | 624 | 138 | 57 | 605 | 137 |
| Düzce | 38 | 374 | 87 | 40 | 347 | 83 |
| Edirne | 65 | 1,122 | 62 | 62 | 1,687 | 57 |
| Elazığ | 33 | 429 | 78 | 37 | 390 | 81 |
| Erzincan | 18 | 218 | 37 | 20 | 211 | 35 |
| Erzurum | 43 | 454 | 81 | 44 | 435 | 76 |
| Eskişehir | 87 | 1,090 | 133 | 84 | 947 | 119 |
| Gaziantep | 128 | 1,720 | 283 | 126 | 1,863 | 264 |
| Giresun | 27 | 328 | 73 | 31 | 366 | 72 |
| Gümüşhane | 6 | 118 | 17 | 7 | 94 | 15 |
| Hakkari | 5 | 78 | 11 | 6 | 84 | 12 |
| Hatay | 115 | 1,402 | 251 | 118 | 1,384 | 246 |

 Table 6
 CO₂ emissions of provinces according to tier-1 method (continued)

| D · | | 2018 | | | 2020 | |
|---------------|----------|--------|-----|----------|--------|-----|
| Provinces | Gasoline | Diesel | LPG | Gasoline | Diesel | LPG |
| Iğdır | 7 | 76 | 12 | 8 | 89 | 11 |
| Isparta | 41 | 362 | 90 | 40 | 312 | 83 |
| İstanbul | 1,650 | 12,523 | 990 | 1,551 | 10,845 | 885 |
| İzmir | 453 | 4,254 | 743 | 450 | 3,585 | 634 |
| Kahramanmaraş | 57 | 658 | 240 | 63 | 621 | 234 |
| Karabük | 19 | 281 | 49 | 19 | 404 | 44 |
| Karaman | 14 | 183 | 46 | 15 | 191 | 45 |
| Kars | 14 | 167 | 20 | 14 | 156 | 20 |
| Kastamonu | 30 | 318 | 87 | 32 | 340 | 81 |
| Kayseri | 105 | 1,215 | 285 | 109 | 1,039 | 262 |
| Kırıkkale | 21 | 651 | 98 | 23 | 506 | 88 |
| Kırklareli | 50 | 447 | 48 | 51 | 483 | 48 |
| Kırşehir | 15 | 156 | 52 | 16 | 161 | 51 |
| Kilis | 12 | 64 | 20 | 12 | 73 | 20 |
| Kocaeli | 199 | 2,651 | 287 | 199 | 2,298 | 267 |
| Konya | 150 | 2,740 | 472 | 150 | 2,243 | 428 |
| Kütahya | 43 | 662 | 129 | 44 | 750 | 117 |
| Malatya | 45 | 461 | 113 | 50 | 424 | 113 |
| Manisa | 124 | 1,481 | 314 | 140 | 1,537 | 295 |
| Mardin | 22 | 412 | 57 | 23 | 543 | 53 |
| Mersin | 156 | 3,946 | 344 | 158 | 2,833 | 341 |
| Muğla | 193 | 1,207 | 236 | 202 | 1,086 | 227 |
| Muş | 8 | 139 | 29 | 9 | 137 | 28 |
| Nevşehir | 23 | 653 | 73 | 24 | 332 | 62 |
| Niğde | 21 | 389 | 65 | 23 | 394 | 65 |
| Ordu | 45 | 448 | 114 | 52 | 463 | 112 |
| Osmaniye | 29 | 368 | 115 | 32 | 283 | 119 |
| Rize | 23 | 276 | 42 | 25 | 277 | 40 |
| Sakarya | 94 | 995 | 245 | 97 | 934 | 225 |
| Samsun | 88 | 1,431 | 214 | 94 | 1,339 | 202 |
| Siirt | 7 | 160 | 15 | 7 | 182 | 19 |
| Sinop | 16 | 145 | 45 | 17 | 132 | 39 |
| Sivas | 39 | 572 | 103 | 40 | 462 | 100 |
| Şanlıurfa | 65 | 787 | 263 | 66 | 863 | 275 |
| Şırnak | 7 | 299 | 18 | 8 | 373 | 20 |
| Tekirdağ | 122 | 1,563 | 155 | 123 | 1,787 | 152 |
| Tokat | 34 | 469 | 98 | 38 | 485 | 97 |

| Duranina | | 2018 | | | 2020 | |
|-----------|----------|--------|-----|----------|--------|-----|
| Provinces | Gasoline | Diesel | LPG | Gasoline | Diesel | LPG |
| Trabzon | 55 | 459 | 101 | 58 | 648 | 94 |
| Tunceli | 4 | 48 | 8 | 4 | 42 | 8 |
| Uşak | 30 | 274 | 78 | 30 | 330 | 74 |
| Van | 31 | 301 | 74 | 31 | 267 | 70 |
| Yalova | 29 | 235 | 32 | 33 | 241 | 30 |
| Yozgat | 20 | 365 | 96 | 22 | 402 | 92 |
| Zonguldak | 43 | 315 | 105 | 44 | 371 | 96 |

Table 6 CO₂ emissions of provinces according to tier-1 method (continued)

Figure 2 CO₂ emissions of fuels used in road transportation according to the tier-1 method, (a) for 2018 (b) for 2020 (see online version for colours)

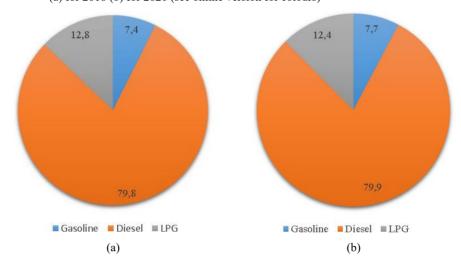


Figure 3 CO₂ emissions in 2018 according to the tier-1 method (see online version for colours)

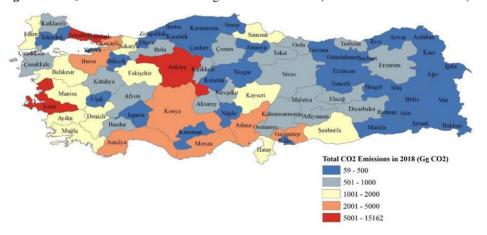


 Table 7
 CO₂ emissions of provinces according to tier-2 method

| Adaman Gor Direct Bundi pase Buse Buse Buse Track Monitor Adaman 1,718 1,718 1,718 1,718 1,718 1,718 1,718 Adaman 1,57 1,718 395 1,718 1,718 1,718 1,718 1,718 Adyomann 1,5 1,47 169 747 | | | | | | 2018 | | | |
|--|-----------------|----------|--------|-------|---------|--------|-------------|--------|------------|
| Gandline Diesel Diese | Provinces | | Car | | Minibus | Bus | Small truck | Truck | Motorcycle |
| nam 157 1,718 395 1,718 1,714 1,714 1,714 1,714 1,714 | | Gasoline | Diesel | DAT | Diesel | Diesel | Dizel | Diesel | Gasoline |
| ann 22 396 107 396 397 397 397 397 397 397 397 397 397 397 397 397 397 397 397 397 397 397 398 397 398 398 398 398 398 398 398 398 398 398 398 | Adana | 157 | 1,718 | 395 | 1,718 | 1,718 | 1,718 | 1,718 | 157 |
| 47 747 | Adıyaman | 22 | 396 | 107 | 396 | 396 | 396 | 396 | 22 |
| (1) (236) (346) (346) (346) (346) (348) (| Afy onkarahisar | 57 | 747 | 169 | 747 | 747 | 747 | 747 | 57 |
| 4 433 | Ağrı | 12 | 236 | 36 | 236 | 236 | 236 | 236 | 12 |
| 1 23 307 82 307 307 307 307 1 626 6,512 1,186 6,512 7,27 <td>Aksaray</td> <td>27</td> <td>433</td> <td>87</td> <td>433</td> <td>433</td> <td>433</td> <td>433</td> <td>27</td> | Aksaray | 27 | 433 | 87 | 433 | 433 | 433 | 433 | 27 |
| 626 6,512 1,186 6,512 5,277 2,270 2,270 2,270 2,270 2,270 2,270 2,270 2,270 2,270 2,270 2,270 2,270 2,270 2,270 2 | Amasya | 23 | 307 | 82 | 307 | 307 | 307 | 307 | 23 |
| n 59 2,277 463 2,277 <td>Ankara</td> <td>626</td> <td>6,512</td> <td>1,186</td> <td>6,512</td> <td>6,512</td> <td>6,512</td> <td>6,512</td> <td>626</td> | Ankara | 626 | 6,512 | 1,186 | 6,512 | 6,512 | 6,512 | 6,512 | 626 |
| n 5 72 72 72 72 13 174 20 174 <t< td=""><td>Antalya</td><td>298</td><td>2,277</td><td>463</td><td>2,277</td><td>2,277</td><td>2,277</td><td>2,277</td><td>298</td></t<> | Antalya | 298 | 2,277 | 463 | 2,277 | 2,277 | 2,277 | 2,277 | 298 |
| ir 13 174 20 174 179 | Ardahan | 5 | 72 | ~ | 72 | 72 | 72 | 72 | S |
| ir 155 951 951 951 951 951 ir 152 1,308 2,41 2,41 2,41 2,41 2,41 | Artvin | 13 | 174 | 20 | 174 | 174 | 174 | 174 | 13 |
| ir 152 1,308 2,4< | Aydın | 125 | 951 | 226 | 951 | 951 | 951 | 951 | 125 |
| 16 124 40 124 125 250 255 250 250 250 250 250 250 250 250 250 250 250 250 250 | Balıkesir | 152 | 1,308 | 232 | 1,308 | 1,308 | 1,308 | 1,308 | 152 |
| 18 323 37 323 323 323 323 323 323 323 323 323 323 323 323 323 323 323 323 324 325 326 570 570 570 570 271 271 271 271 271 272 272 272 272 273 273 273 273 | Bartın | 16 | 124 | 40 | 124 | 124 | 124 | 124 | 16 |
| t 4 56 9 56 56 56 56 56 56 56 56 56 56 56 56 56 | Batman | 18 | 323 | 37 | 323 | 323 | 323 | 323 | 18 |
| 20 255 36 255 255 255 8 110 23 110 110 110 110 46 166 28 166 166 166 166 25 489 478 478 478 478 329 2,700 2,700 2,700 2,700 2,700 ale 81 586 91 586 586 586 13 27 41 227 227 227 227 34 1,386 1,386 1,386 1,386 1,386 4kr 55 624 1,386 1,386 1,386 4kr 55 624 324 324 324 | Bayburt | 4 | 99 | 6 | 56 | 56 | 56 | 56 | 4 |
| 8 110 23 110 | Bilecik | 20 | 255 | 36 | 255 | 255 | 255 | 255 | 20 |
| 9 166 28 166 168 168 478 478 478 478 478 478 478 489 | Bingöl | ∞ | 110 | 23 | 110 | 110 | 110 | 110 | ∞ |
| 46 478 478 478 478 478 478 478 478 478 478 478 478 478 478 478 478 478 478 478 489 480 586 587 587 587 587 587 587 587 587 587 584 587 584 587 584 587 584 587 587 587 587 587 587 587 587 587 | Bitlis | 6 | 166 | 28 | 166 | 166 | 166 | 166 | 6 |
| 25 489 73 489 480 5700 5700 5700 5700 5700 570 577 577 577 577 577 473< | Bolu | 46 | 478 | 82 | 478 | 478 | 478 | 478 | 46 |
| ale 81 586 91 5700 2,700 2,700 2,700 2,700 2,700 2,700 ale 81 586 91 586 586 586 586 586 586 586 586 586 586 | Burdur | 25 | 489 | 73 | 489 | 489 | 489 | 489 | 25 |
| ale 81 586 91 586 586 586 586 586 586 586 586 586 586 586 586 586 586 586 586 587 527 227 227 227 227 227 227 227 227 473 | Bursa | 329 | 2,700 | 350 | 2,700 | 2,700 | 2,700 | 2,700 | 329 |
| 13 227 41 227 227 227 227 227 227 227 227 227 227 473 474 473 473 474 473 473 474 473 473 473 474 473 474 473 474 474 474 474 474 474 474 474 474 474 474 474 474 474 | Çanakkale | 81 | 989 | 91 | 586 | 586 | 586 | 586 | 81 |
| 33 473 126 473 473 473 473 93 1,386 227 1,386 1,386 1,386 1,386 skr 55 624 138 624 624 624 38 374 87 324 324 324 324 | Çankırı | 13 | 227 | 41 | 227 | 227 | 227 | 227 | 13 |
| 93 1,386 227 1,386 1,386 1,386 1,386 ikir 55 624 138 624 624 624 38 374 87 324 324 324 324 | Çorum | 33 | 473 | 126 | 473 | 473 | 473 | 473 | 33 |
| ukır 55 624 138 624 624 624 624 624 38 374 87 324 324 324 324 | Denizli | 93 | 1,386 | 227 | 1,386 | 1,386 | 1,386 | 1,386 | 93 |
| 38 374 87 324 324 324 324 | Diyarbakır | 55 | 624 | 138 | 624 | 624 | 624 | 624 | 55 |
| | Düzce | 38 | 374 | 87 | 324 | 324 | 324 | 324 | 38 |

 Table 7
 CO2 emissions of provinces according to tier-2 method (continued)

| | | | | | 2018 | | | |
|---------------|----------|--------|-----|---------|--------|-------------|--------|------------|
| Provinces | | Car | | Minibus | Bus | Small truck | Truck | Motorcycle |
| - | Gasoline | Diesel | DAT | Diesel | Diesel | Dizel | Diesel | Gasoline |
| Edime | 65 | 1,122 | 62 | 1,122 | 1,122 | 1,122 | 1,122 | 65 |
| Elazığ | 33 | 429 | 78 | 429 | 429 | 429 | 429 | 33 |
| Erzurum | 18 | 218 | 37 | 218 | 218 | 218 | 218 | 18 |
| Erzincan | 43 | 454 | 81 | 454 | 454 | 454 | 454 | 43 |
| Eskişehir | 87 | 1,090 | 133 | 1,090 | 1,090 | 1,090 | 1,090 | 87 |
| Gaziantep | 128 | 1,720 | 283 | 1,720 | 1,720 | 1,720 | 17,220 | 128 |
| Giresun | 27 | 328 | 73 | 328 | 328 | 328 | 328 | 27 |
| Gümüşhane | 9 | 118 | 17 | 118 | 118 | 118 | 118 | 9 |
| Hakkari | Ś | 78 | 111 | 78 | 78 | 78 | 78 | S |
| Hatay | 115 | 1,402 | 251 | 1,402 | 1,402 | 1,402 | 1,402 | 115 |
| Iğdır | 7 | 92 | 12 | 92 | 92 | 92 | 92 | 7 |
| Isparta | 41 | 362 | 06 | 362 | 362 | 362 | 362 | 41 |
| İstanbul | 1,650 | 12,523 | 066 | 12,523 | 12,523 | 12,523 | 12,523 | 1,650 |
| İzmir | 453 | 4,254 | 743 | 4,254 | 4,254 | 4,254 | 4,254 | 453 |
| Kahramanmaraş | 57 | 658 | 240 | 658 | 859 | 658 | 658 | 57 |
| Karabük | 19 | 281 | 49 | 281 | 281 | 281 | 281 | 19 |
| Karaman | 14 | 183 | 46 | 183 | 183 | 183 | 183 | 14 |
| Kars | 14 | 167 | 20 | 167 | 167 | 167 | 167 | 14 |
| Kastamonu | 30 | 318 | 87 | 318 | 318 | 318 | 318 | 30 |
| Kayseri | 105 | 1,215 | 285 | 1,215 | 1,215 | 1,215 | 1,215 | 105 |
| Kırıkkale | 21 | 651 | 86 | 651 | 651 | 651 | 651 | 21 |
| Kırklareli | 50 | 447 | 48 | 447 | 447 | 447 | 447 | 50 |
| Kırşehir | 15 | 156 | 52 | 156 | 156 | 156 | 156 | 15 |
| Kilis | 12 | 64 | 20 | 64 | 64 | 64 | 64 | 12 |
| Kocaeli | 199 | 2,651 | 287 | 2,651 | 2,651 | 2,651 | 2,651 | 199 |
| Konya | 150 | 2,740 | 472 | 2,740 | 2,740 | 2,740 | 2,740 | 150 |
| Kütahya | 43 | 662 | 129 | 662 | 662 | 662 | 662 | 43 |
| | | | | | | | | |

Table 7 CO₂ emissions of provinces according to tier-2 method (continued)

| Provinces Gar Manthes Buss Small track Irrack Mono Mankaya 45 461 113 461 461 461 1481 461 | | | | | | 2018 | | | |
|---|-----------|----------|--------|-----|---------|--------|-------------|--------|------------|
| Ganoline Diesel Diesel Diesel Diesel Diesel 45 461 113 461 461 461 461 461 124 1481 1 | Provinces | | Car | | Minibus | Bus | Small truck | Truck | Motorcycle |
| 45 461 113 461 462 | | Gasoline | Diesel | DAT | Diesel | Diesel | Dizel | Diesel | Gasoline |
| 124 1,481 314 1,481 1,4 | Malatya | 45 | 461 | 113 | 461 | 461 | 461 | 461 | 45 |
| 22 412 412 412 412 412 412 412 412 412 412 412 412 412 412 1207 3946 3948 | Manisa | 124 | 1,481 | 314 | 1,481 | 1,481 | 1,481 | 1,481 | 124 |
| 156 3,948 3,948 3,948 3,948 3,83 3,84 | Mardin | 22 | 412 | 57 | 412 | 412 | 412 | 412 | 22 |
| 193 1,207 236 1,207 1,2 | Mersin | 156 | 3,946 | 344 | 3,946 | 3,946 | 3,946 | 3,946 | 156 |
| 8 139 29 138 138 149 148 149 149 149 149 149 149 149 149 149 149 149 149 149 149 149 149 149 149 149 | Muğla | 193 | 1,207 | 236 | 1,207 | 1,207 | 1,207 | 1,207 | 193 |
| 23 653 | Muş | & | 139 | 29 | 139 | 139 | 139 | 139 | ∞ |
| 21 389 589 389 389 389 389 389 389 389 389 389 389 389 389 389 389 389 389 448 | Nevşehir | 23 | 653 | 73 | 653 | 653 | 653 | 653 | 23 |
| 45 448 | Niğde | 21 | 389 | 65 | 389 | 389 | 389 | 389 | 21 |
| 29 368 369 | Ordu | 45 | 448 | 114 | 448 | 448 | 448 | 448 | 45 |
| 23 276 276 276 276 276 276 276 276 276 276 276 276 276 276 276 276 276 276 278 278 278 278 278 278 278 145 146 146 146 146 146 146 146 | Osmaniye | 29 | 368 | 115 | 368 | 368 | 368 | 368 | 29 |
| 94 995 995 995 995 88 1,431 214 1,431 | Rize | 23 | 276 | 42 | 276 | 276 | 276 | 276 | 23 |
| 88 1,431 1441 1,431 1,431 1,431 1,431 1,431 1,431 1,431 1,431 1,431 1,431 1,431 1,431 1,431 1,431 1,431 1,431 1,431 1,431 1,60 | Sakarya | 94 | 995 | 245 | 995 | 995 | 995 | 995 | 94 |
| 7 160 16 160 | Samsun | 88 | 1,431 | 214 | 1,431 | 1,431 | 1,431 | 1,431 | 88 |
| 16 145 45 146 148 148 148 148 148 148 148 148 148 148 148 148 148 148 148 148 148 148 148 | Siirt | 7 | 160 | 16 | 160 | 160 | 160 | 160 | 7 |
| 39 572 103 572 572 572 65 787 787 787 787 787 7 299 1,8 299 299 299 122 1,563 1,563 1,563 1,563 1,563 34 469 98 469 | Sinop | 16 | 145 | 45 | 145 | 145 | 145 | 145 | 16 |
| 65 787 787 787 787 787 7 299 18 299 299 299 299 152 1,563 1,563 1,563 1,563 299 299 34 469 8 469 469 469 469 469 4 48 8 48 48 48 48 48 30 274 78 274 274 274 274 31 301 74 301 301 301 301 20 235 235 235 235 235 20 365 365 365 365 365 43 315 105 315 315 315 315 | Sivas | 39 | 572 | 103 | 572 | 672 | 572 | 572 | 39 |
| 7 299 18 299 269 469 469 469 469 469 469 469 469 469 469 469 469 469 469 478 48 < | Şanlıurfa | 65 | 787 | 263 | 787 | 787 | 787 | 787 | 65 |
| 122 1,563 1,563 1,563 1,563 1,563 34 469 98 469 469 469 469 469 55 759 101 759 759 759 759 4 48 8 48 48 48 48 48 30 274 78 274 274 274 274 274 31 301 74 301 301 301 301 301 29 235 32 235 235 235 235 20 365 365 365 365 365 365 43 315 105 315 315 315 315 | Şırnak | 7 | 299 | 18 | 299 | 299 | 299 | 299 | 7 |
| 34 469 759 759 759 759 759 759 759 759 759 759 759 759 759 754 759 754 | Tekirdağ | 122 | 1,563 | 155 | 1,563 | 1,563 | 1,563 | 1,563 | 122 |
| 55 759 101 759 759 759 759 4 48 8 48 48 48 48 48 30 274 78 274 274 274 274 31 301 74 301 301 301 301 29 235 235 235 235 235 20 365 96 365 365 365 43 315 105 315 315 315 | Tokat | 34 | 469 | 86 | 469 | 469 | 469 | 469 | 34 |
| 4 48 574 | Trabzon | 55 | 759 | 101 | 759 | 759 | 759 | 759 | 55 |
| 30 274 78 274 | Tunceli | 4 | 48 | ∞ | 48 | 48 | 48 | 48 | 4 |
| 31 301 74 301 301 301 301 29 235 235 235 235 235 235 20 365 96 365 365 365 365 43 315 105 315 315 315 315 | Uşak | 30 | 274 | 78 | 274 | 274 | 274 | 274 | 30 |
| 29 235 32 235 235 235 20 365 96 365 365 365 43 315 105 315 315 315 | Van | 31 | 301 | 74 | 301 | 301 | 301 | 301 | 31 |
| 20 365 36 365 365 365 43 315 105 315 315 315 | Yalova | 29 | 235 | 32 | 235 | 235 | 235 | 235 | 29 |
| 43 315 105 315 315 315 315 | Yozgat | 20 | 365 | 96 | 365 | 365 | 365 | 365 | 20 |
| | Zonguldak | 43 | 315 | 105 | 315 | 315 | 315 | 315 | 43 |

 Table 7
 CO2 emissions of provinces according to tier-2 method (continued)

| | | | | | 2020 | | | |
|----------------|----------|--------|-------|---------|--------|-------------|--------|------------|
| Provinces | | Car | | Minibus | Bus | Small truck | Truck | Motorcycle |
| | Gasoline | Diesel | DAT | Diesel | Diesel | Dizel | Diesel | Gasoline |
| Adana | 161 | 1,776 | 384 | 1,776 | 1,776 | 1,776 | 1,776 | 161 |
| Adıyaman | 24 | 312 | 66 | 312 | 312 | 312 | 312 | 24 |
| Afyonkarahisar | 62 | 924 | 160 | 924 | 924 | 924 | 924 | 62 |
| Ağrı | 13 | 236 | 33 | 236 | 236 | 236 | 236 | 13 |
| Aksaray | 32 | 463 | 84 | 463 | 463 | 463 | 463 | 32 |
| Amasya | 24 | 301 | 84 | 301 | 301 | 301 | 301 | 24 |
| Ankara | 969 | 6,398 | 1,048 | 6,398 | 6,398 | 6,398 | 6,398 | 969 |
| Antalya | 292 | 2,060 | 445 | 2,060 | 2,060 | 2,060 | 2,060 | 292 |
| Ardahan | 9 | 348 | 10 | 348 | 348 | 348 | 348 | 9 |
| Artvin | 14 | 187 | 20 | 187 | 187 | 187 | 187 | 14 |
| Aydın | 128 | 1,722 | 208 | 1,722 | 1,722 | 1,722 | 1,722 | 128 |
| Balıkesir | 163 | 1,326 | 223 | 1,326 | 1,326 | 1,326 | 1,326 | 163 |
| Bartın | 16 | 109 | 38 | 109 | 109 | 109 | 109 | 16 |
| Batman | 17 | 526 | 33 | 526 | 526 | 526 | 526 | 17 |
| Bayburt | 4 | 53 | 6 | 53 | 53 | 53 | 53 | 4 |
| Bilecik | 21 | 241 | 35 | 241 | 241 | 241 | 241 | 21 |
| Bingöl | 6 | 106 | 19 | 106 | 106 | 106 | 106 | 6 |
| Bitlis | 6 | 188 | 26 | 188 | 188 | 188 | 188 | 6 |
| Bolu | 51 | 428 | 92 | 428 | 428 | 428 | 428 | 51 |
| Burdur | 25 | 398 | 99 | 398 | 398 | 398 | 398 | 25 |
| Bursa | 336 | 2,611 | 329 | 2,611 | 2,611 | 2,611 | 2,611 | 336 |
| Çanakkale | 82 | 644 | 81 | 644 | 644 | 644 | 644 | 82 |
| Çankırı | 15 | 423 | 38 | 423 | 423 | 423 | 423 | 15 |
| Çorum | 38 | 559 | 117 | 559 | 559 | 559 | 559 | 38 |
| Denizli | 92 | 1,840 | 210 | 1,840 | 1,840 | 1,840 | 1,840 | 92 |
| Diyarbakır | 57 | 909 | 137 | 909 | 909 | 909 | 605 | 57 |
| Düzce | 40 | 347 | 83 | 347 | 347 | 347 | 347 | 40 |

Table 7 CO₂ emissions of provinces according to tier-2 method (continued)

| Formitees Gar Indinates Blase Small tracks Track Autorops Edange Orasolhor Diesel 1,687 1,68 | | | | | | 2020 | | | |
|---|---------------|----------|--------|-----|---------|--------|-------------|--------|------------|
| Gazooline Diesel Dies | Provinces | | Car | | Minibus | Bus | Small truck | Truck | Motorcycle |
| 62 1687 57 1687 1687 1687 1687 1687 1687 1687 168 | • | Gasoline | Diesel | DAT | Diesel | Diesel | Dizel | Diesel | Gasoline |
| 37 390 81 390 390 390 44 435 41 211 211 211 211 84 44 435 76 435 435 435 435 1 84 974 19 974 | Edime | 62 | 1,687 | 57 | 1,687 | 1,687 | 1,687 | 1,687 | 62 |
| 20 211 35 211 211 211 211 211 211 211 211 211 211 211 211 211 435 436 436 368 368 368 368 368 368 368 368 368 368 368 368 368 | Elazığ | 37 | 390 | 81 | 390 | 390 | 390 | 390 | 37 |
| 44 455 76 435 435 435 435 435 435 435 435 435 435 435 435 435 435 435 435 1,863 | Erzurum | 20 | 211 | 35 | 211 | 211 | 211 | 211 | 20 |
| p 126 1184 974 | Erzincan | 44 | 435 | 92 | 435 | 435 | 435 | 435 | 44 |
| p 126 1,863 264 1,863 1,863 1,863 1,863 1,863 1,863 1,863 1,863 1,863 1,863 1,863 1,863 1,863 1,863 1,863 366 367 368 368 368 368 368 368 368 368 368 368 368 368 368 368 368 369 369 369 369 369 369 369 369 369 369 369 369 369 369 369 <t< td=""><td>Eskişehir</td><td>\$</td><td>974</td><td>119</td><td>974</td><td>974</td><td>974</td><td>974</td><td>84</td></t<> | Eskişehir | \$ | 974 | 119 | 974 | 974 | 974 | 974 | 84 |
| nne 7 366 367 367 367 367 367 367 367 367 368 368 368 368 368 368 368 368 368 368 369 369 369 369 369 369 369 369 369 369 369 | Gaziantep | 126 | 1,863 | 264 | 1,863 | 1,863 | 1,863 | 1,863 | 126 |
| nne 7 94 15 94< | Giresun | 31 | 366 | 72 | 366 | 366 | 366 | 366 | 31 |
| 6 8 84 12 84 84 84 84 84 84 84 84 84 84 84 84 84 | Gümüşhane | 7 | 94 | 15 | 94 | 94 | 94 | 94 | 7 |
| 118 1,384 246 1,384 1,384 1,384 1,384 1,384 1,384 1,384 1,384 1,384 1,384 1,384 1,384 1,384 1,384 1,384 89 80 | Hakkari | 9 | 84 | 12 | 84 | 84 | 84 | 84 | 9 |
| 8 89 10 40 41 81 112 112 112 10 845 10 845 10 845 10 845 10 845 10 845 10 845 10 845 10 845 10 845 845 10 845 | Hatay | 118 | 1,384 | 246 | 1,384 | 1,384 | 1,384 | 1,384 | 118 |
| 40 312 83 312 | Iğdır | ∞ | 68 | 111 | 68 | 68 | 68 | 68 | 8 |
| 1,551 10,845 885 10,844 10,944 40,44 | Isparta | 40 | 312 | 83 | 312 | 312 | 312 | 312 | 40 |
| 450 3,585 6,34 3,585 404 | İstanbul | 1,551 | 10,845 | 885 | 10,845 | 10,845 | 10,845 | 10,845 | 1,551 |
| mmaraş 63 621 622 622 623 623 623 623 623 623 623 624 </td <td>İzmir</td> <td>450</td> <td>3,585</td> <td>634</td> <td>3,585</td> <td>3,585</td> <td>3,585</td> <td>3,585</td> <td>450</td> | İzmir | 450 | 3,585 | 634 | 3,585 | 3,585 | 3,585 | 3,585 | 450 |
| 19 404 44 404 404 404 404 404 15 191 45 191 191 191 191 14 156 20 156 156 156 156 10 1,039 262 1,039 1,039 1,039 1,039 1 23 506 88 506 506 506 506 1 48 48 483 483 483 483 1 161 </td <td>Kahramanmaraş</td> <td>63</td> <td>621</td> <td>234</td> <td>621</td> <td>621</td> <td>621</td> <td>621</td> <td>63</td> | Kahramanmaraş | 63 | 621 | 234 | 621 | 621 | 621 | 621 | 63 |
| 15 191 45 191 150 | Karabük | 19 | 404 | 44 | 404 | 404 | 404 | 404 | 19 |
| nu 15 15 15 156 156 156 156 156 156 156 156 156 156 156 156 156 156 156 157 153 150 | Karaman | 15 | 191 | 45 | 191 | 191 | 191 | 191 | 15 |
| nu 32 340 81 340 350 | Kars | 14 | 156 | 20 | 156 | 156 | 156 | 156 | 14 |
| 109 1,039 262 1,039 1,039 1,039 1,039 1,039 i 23 506 88 506 506 506 506 i 51 483 483 483 483 483 483 16 161 51 161 161 161 161 161 12 73 20 73 73 73 73 150 2,298 2,298 2,298 2,298 2,298 150 2,243 428 2,243 2,243 2,243 44 750 117 750 750 750 | Kastamonu | 32 | 340 | 81 | 340 | 340 | 340 | 340 | 32 |
| 5 506 88 506 507 73 73 73 73 73 73 73 73 73 73 73 7208 7208 7208 7208 7208 7208 7208 7204 750 750 750 750 750 | Kayseri | 109 | 1,039 | 262 | 1,039 | 1,039 | 1,039 | 1,039 | 109 |
| i 48 483 484 484 484 484 480 484 480 | Kırıkkale | 23 | 909 | 88 | 909 | 909 | 909 | 206 | 23 |
| 16 161 51 161 173 74 74 75 | Kırklareli | 51 | 483 | 48 | 483 | 483 | 483 | 483 | 51 |
| 12 73 20 73 75< | Kırşehir | 16 | 161 | 51 | 161 | 161 | 161 | 161 | 16 |
| 199 2,298 267 2,298 2,298 2,298 2,298 2,298 2,298 2,298 2,298 2,298 2,298 2,243 2,243 2,243 2,243 2,243 2,243 2,243 44 750 117 750 750 750 750 | Kilis | 12 | 73 | 20 | 73 | 73 | 73 | 73 | 12 |
| 150 2,243 428 2,243 2,243 2,243 44 750 117 750 750 750 | Kocaeli | 199 | 2,298 | 267 | 2,298 | 2,298 | 2,298 | 2,298 | 199 |
| 44 750 117 750 750 750 750 | Konya | 150 | 2,243 | 428 | 2,243 | 2,243 | 2,243 | 2,243 | 150 |
| | Kütahya | 44 | 750 | 117 | 750 | 750 | 750 | 750 | 44 |

 Table 7
 CO2 emissions of provinces according to tier-2 method (continued)

| Provinces Car Malatya 50 424 Manisa 140 1,537 Mardin 23 543 Mersin 158 2,833 Muğla 202 1,086 Muş 9 137 Nevşehir 24 332 Niğde 23 394 Ordu 52 463 Osmaniye 32 283 Rize 25 277 Sakarya 97 934 Samsun 94 1,339 Siirt 7 182 | LPG 113 295 53 341 227 28 62 65 112 | Minibus Diesel 424 1,537 543 2,833 1,086 137 332 | Bus Diesel 424 1,537 543 | Small truck Dizel | Truck Diesel | Motorcycle Gasoline |
|--|--|---|-------------------------------|-------------------|-----------------|------------------------|
| Gasoline 50 140 23 158 202 9 24 23 32 32 97 7 | 113 295 53 53 341 227 28 62 65 | Diesel 424 1,537 543 2,833 1,086 137 332 | Diesel 424 1,537 543 | Dizel | Diesel | Gasoline |
| 50 140 158 202 9 24 23 32 97 | 113 295 53 341 227 28 62 62 | 424 1,537 543 2,833 1,086 137 332 | 424 1,537 543 | 707 | | |
| 140 23 158 202 9 24 52 32 32 97 | 295 53 341 227 28 62 65 112 | 1,537 543 2,833 1,086 137 332 | 1,537 | 474 | 424 | 50 |
| 23 158 202 9 23 32 32 77 | 53 341 227 28 62 65 112 | 543 2,833 1,086 137 332 | 543 | 1,537 | 1,537 | 140 |
| 158 202 9 24 23 32 25 77 | 341 227 28 62 65 112 | 2,833 1,086 137 332 | | 543 | 543 | 23 |
| 202 9 23 23 32 32 25 7 4 | 227 28 62 65 112 | 1,086 137 332 | 2,833 | 2,833 | 2,833 | 158 |
| 9 23 32 32 97 7 | 28 62 65 112 119 | 137 | 1,086 | 1,086 | 1,086 | 202 |
| 24 52 32 32 97 7 | 62 65 112 119 | 332 | 137 | 137 | 137 | 6 |
| 23 32 32 97 7 | 65 112 119 | | 332 | 332 | 332 | 24 |
| 52 32 25 94 7 | 112 | 394 | 394 | 394 | 394 | 23 |
| 32 25 97 7 | 119 | 463 | 463 | 463 | 463 | 52 |
| 25 97 7 | | 283 | 283 | 283 | 283 | 32 |
| 97 94 | 40 | 277 | 277 | 277 | 277 | 25 |
| 94 | 225 | 934 | 934 | 934 | 934 | 76 |
| 7 | 202 | 1,339 | 1,339 | 1,339 | 1,339 | 94 |
| | 19 | 182 | 182 | 182 | 182 | 7 |
| Sinop 17 132 | 39 | 132 | 132 | 132 | 132 | 17 |
| 40 | 100 | 462 | 462 | 462 | 462 | 40 |
| Şanlıurfa 66 863 | 275 | 863 | 863 | 863 | 863 | 99 |
| Şırnak 8 373 | 20 | 373 | 373 | 373 | 373 | & |
| 123 | 152 | 1,787 | 1,787 | 1,787 | 1,787 | 123 |
| 38 | 26 | 485 | 485 | 485 | 485 | 38 |
| Trabzon 58 648 | 94 | 648 | 648 | 648 | 648 | 58 |
| Tunceli 4 42 | ∞ | 42 | 42 | 42 | 42 | 4 |
| Uşak 30 330 | 74 | 330 | 330 | 330 | 330 | 30 |
| Van 31 267 | 70 | 267 | 267 | 267 | 267 | 31 |
| Yalova 33 241 | 30 | 241 | 241 | 241 | 241 | 33 |
| Yozgat 22 402 | 92 | 402 | 402 | 402 | 402 | 22 |
| Zonguldak 44 371 | 96 | 371 | 371 | 371 | 371 | 44 |

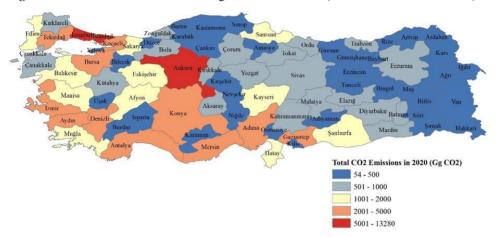
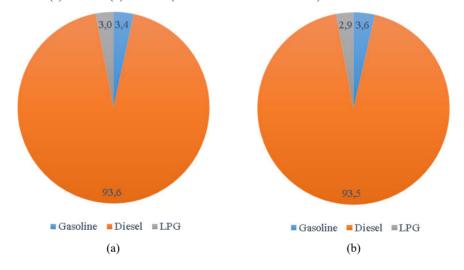


Figure 4 CO₂ emissions in 2020 according to the tier-1 method (see online version for colours)

Figure 5 CO₂ emissions of fuels used in road transportation according to the tier-2 method, (a) for 2018 (b) for 2020 (see online version for colours)



3.2 Carbon footprint by tier-2 method

According to the Tier 2 method, CO₂ emissions for all provinces were calculated and presented in Table 7. Looking at Table 7, it is seen that diesel fuels have the highest CO₂ emissions and LPG has the lowest CO₂ emissions among the fuels consumed in Turkey. When Table 7 is analysed on a provincial basis: Although CO₂ emissions from gasoline are lower than those from LPG in most of the provinces, in some densely populated provinces, especially Ankara, Istanbul and Izmir, LPG-originated CO₂ emissions are lower than gasoline-originated CO₂ emissions, resulting in a lower total LPG-originated CO₂ emission than gasoline-originated CO₂ emissions. In Figure 5, the CO₂ emissions generated by the fuel consumed for 2018 and 2020, respectively, are presented. In the calculations made according to the tier-1 method, it is seen in Figure 5 that the CO₂

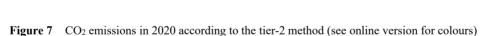
Burdur

Muğla

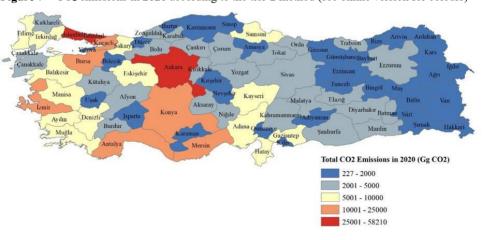
emissions from gasoline are 3.4% and 3.6%, the CO₂ emissions from diesel fuel are 93.6% and 93.5%, and the CO₂ emissions from LPG are 3.0% and 2.9%, for 2018 and 2020 respectively. Figure 5 shows that there is no significant difference between 2018 and 2020 in the CO₂ emission values. According to the tier-1 method, it is seen in Figure 6, Figure 7 and Table 7 that Istanbul, Ankara and Izmir have the highest CO₂ emissions in Turkey respectively for 2018 and 2020, followed by the big cities. Again, when Figures 6 and 7 are examined, it is seen that western provinces have higher CO₂ emissions than eastern provinces. It is thought that CO₂ emissions are high as a result of the higher population density of the western provinces, similar to Figure 3 and Figure 4. Dündar (2021), similarly, used the Tier 1 method in his study investigating the greenhouse gas emissions of big cities and stated that the highest greenhouse gas emissions belonged to the provinces of Istanbul, Ankara and Izmir, while the greenhouse gas emissions were lower in the provinces further east.

Kurklareli Bartun Kastamona Sinop Samsun Corum Annasya Ordu Giresun Trabzon Rize Artvin Ardahan Sinop Samsun Tokard Giresun Giresun Giresun Giresun Giresun Giresun Giresun Giresun Fizzurum Igdir Kasta Kurklare Yozgal Sivas Ezzincan Fizzurum Igdir Kutahya Manisa Usak Afyon Nevsehir Kayseri Malatya Elazig Bittis Van Diyarbakir Batman Siirt

Figure 6 CO₂ emissions in 2018 according to the tier-2 method (see online version for colours)



Total CO2 Emissions in 2018 (Gg CO2)



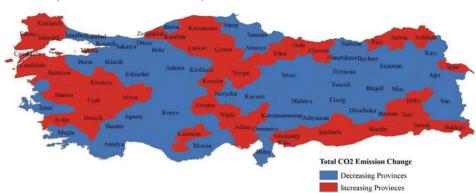
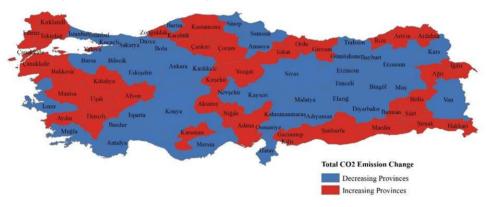


Figure 8 Change in CO₂ emissions between 2018 and 2020 according to the tier-1 method (see online version for colours)

Figure 9 Change in CO₂ emissions between 2018 and 2020 according to the tier-2 method (see online version for colours)



As a result of the study, provinces with increasing and decreasing CO₂ emissions between 2018 and 2020 according to tier-1 and tier-2 methods were determined and presented in Figures 8 and 9. The only difference between the two methods is seen in Ağrı province. While CO₂ emission decreased according to tier-1 method for Ağrı province, it increased according to tier-2 method. However, it is only about 1 Gg CO₂ in increase and decrease, and it is at a negligible level. In 2020, CO2 emissions increased in about half of the provinces compared to 2018, while a decrease was observed in about half of them. Istanbul, Ankara and Izmir came first among the provinces that saw reductions in CO₂ emissions. Since these provinces have the highest CO₂ emissions, CO₂ emissions have decreased all over Turkey. This decrease was 3.4% according to the tier-1 method and 3.0% according to the tier-2 method. Looking at Turkey's total CO₂ emissions, it was 95,689 Gg CO₂ for 2018 and 92,424 Gg CO₂ for 2020, according to the tier-1 method, while it was 417,359 Gg CO₂ for 2018 and 404,631 Gg CO₂ for 2020 according to tier-2 calculations. Since more specific data are used in the tier-2 method, it is thought that the tier-2 method gives more accurate results. The results of the calculations made according to the tier-2 method were found to be approximately 4-5 times higher than the results of the studies carried out according to the tier-1 method. In the study conducted by Bıyık and Civelekoğlu (2021) for the province of Isparta, it was stated that the results of the tier-2 method were higher than the tier-1 method at similar rates. Dündar (2021) calculated CO₂ emissions in 30 big cities in Turkey in 2010 and 2019 according to the tier-1 method and stated that they were 40,403 Gg CO₂ and 70,271 Gg CO₂, respectively. Soylu (2007), on the other hand, stated that the CO₂ emission originating from road transportation in Turkey for 2004 was 36,858 kt according to the COPERT III method.

4 Discussion

The transportation sector is among the main sectors that generate CO₂ emissions. It is known that road transportation has the highest CO₂ emission among the transportation sector. As a result of the study, Turkey's carbon footprint from road transportation in 2018 and 2020 was calculated. IPCC tier-1 and tier-2 approaches were used in the study. While there was a 3.4% reduction in CO₂ emissions according to the tier-1 method in 2020, there was a 3% reduction according to the tier-2 method. In 2020, it was observed that CO₂ emissions decreased from 95,689 Gg CO₂ to 92,424 Gg CO₂ according to the tier-1 method, and from 417,359 Gg CO₂ to 404,631 Gg CO₂ according to the tier-2 method. In fuels used in vehicles, it was determined that diesel fuels cause the highest CO₂ emissions in both tier-1 and tier-2 methods. In the study, it was seen that Istanbul, Ankara and Izmir have the highest CO₂ emissions among the provinces in Turkey, respectively. As a result of the study, it was observed that CO₂ emissions increased in parallel with the population, but the small decrease in CO₂ emissions in 2020 is a promising situation for Turkey.

As a result of the study, it is possible to suggest some solutions for reducing CO₂ emissions and carbon footprints caused by road transportation in Turkey. Based on the knowledge that a tree absorbs 12 kg of CO₂ per year during photosynthesis, afforestation efforts in cities should be accelerated without delay. Instead of using private vehicles, people should be encouraged to use public transportation and, where possible, pedestrian transportation. Alternative modes of transportation such as railway and seaway should be expanded. Non-motorised transportation should be encouraged by providing adequate bicycle lanes. The use of vehicles with hybrid technology should be expanded. Vehicles should be maintained regularly.

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