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Determination of CO_2 Emission Based on Fuel Consumption in Wheat and Corn Production in TR 62 Region and Projection Estimate

Ebubekir ALTUNTAŞ[1*]

[1]Tokat Gaziosmanpasa University, Faculty of Agriculture, Department of Biosystems Engineering, Tokat
***Corresponding author's email:** ebubekir.altuntas@gop.edu.tr

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Abstract: This study aims to determine the carbon dioxide emission based on fuel consumption in wheat and corn production of Adana and Mersin provinces covering TR62 Region between 2014 and 2023 years and to estimate the projection for future years. The average CO_2 emission, specific fuel consumption and specific CO_2 emission values of TR62 Region based on fuel consumption in wheat production are 87.19 $ktCO_2$, 30.80 $g_{fuel}\ kg_{product}^{-1}$ and 105. 29 $gCO_2\ kg_{product}^{-1}$, while in corn production between 2014 and 2023 years, the average CO_2 emission, specific fuel consumption and specific CO_2 emission values for the same years were determined as 37.13 $ktCO_2$, 100.97 $g_{fuel}\ kg_{crop}^{-1}$ and 345.19 $gCO_2\ kg_{product}^{-1}$ respectively. Total CO_2 emissions are expected to decrease, while specific fuel consumption and specific CO_2 emission values are expected to increase according to the future projections calculated between 2024 and 2033 years in wheat and corn production in TR62 Region.

Keywords: Total CO_2 emission, specific fuel consumption, specific CO_2 emission, projection coefficient

TR 62 Bölgesinin Buğday ve Mısır Üretiminde Yakıt Tüketimine Dayalı CO_2 Emisyonunun Belirlenmesi ve Projeksiyon Tahmini

Özet: Bu çalışma, TR62 Bölgesini kapsayan Adana ve Mersin illerinin 2014-2023 yılları arasındaki buğday ve mısır üretimindeki yakıt tüketimine dayalı karbondioksit emisyonunu belirlemeyi ve gelecek yıllara ait projeksiyon tahminini amaçlamıştır. TR62 Bölgesinin 2014-2023 yılları arasındaki buğday üretimindeki yakıt tüketimine dayalı olarak meydana gelen ortalama CO_2 emisyonu, özgül yakıt tüketimi ve özgül CO_2 emisyonu değerleri sırasıyla 87.19 $ktCO_2$, 30.80 $g_{yakıt}\ kg_{ürün}^{-1}$ ve 105.29 $gCO_2\ kg_{ürün}^{-1}$ olarak belirlenirken, mısır üretiminde ise aynı yıllara ait ortalama CO_2 emisyonu, özgül yakıt tüketimi ve özgül CO_2 emisyonu değerleri de sırasıyla 37.13 $ktCO_2$, 100.97 $g_{yakıt}\ kg_{ürün}^{-1}$ ve 345.19 $gCO_2\ kg_{ürün}^{-1}$ olarak belirlenmiştir. TR62 Bölgesinin buğday ve mısır üretiminde 2024-2033 yıllarına ait hesaplanan gelecek projeksiyon tahminlerine göre, toplam CO_2 emisyonunun düşme eğiliminde, buna karşın özgül yakıt tüketimi ve özgül CO_2 emisyon değerlerinin ise artma eğiliminde olacağı öngörülmektedir.

Anahtar Kelimeler: Toplam CO_2 emisyonu, özgül yakıt tüketimi, özgül CO_2 emisyonu, projeksiyon katsayısı

1. Introduction

The agricultural production sector is not only affected by climate change but also causes climate change. Although the industrial agriculture and food production system is profitable and efficient, it also causes many health, environmental and economic problems. The tillage, sowing-planting-maintenance, irrigation, spraying, harvesting and post-harvest operations cause climate change and thus the formation of greenhouse gas emissions in the agricultural production sector (Lal, 2004; Massey et al., 2019). The productivity and profitability are evaluated together with the energy consumed in agricultural production. There is an increase in exhaust emissions and greenhouse gas emissions from fuel and engine oil consumed by tractors and agricultural machinery due to the change and development in agricultural production technologies (Küsek, 2018).

The total greenhouse gas emission for 2015 was 475 $MtCO_2$ equivalent and it is explained that 72% (340 $MtCO_2$ equivalent) of the total emission was from energy, 13% (61 $MtCO_2$ equivalent) from industrial processes, 12% (57 $MtCO_2$ equivalent) from agriculture and 3% (17 $MtCO_2$ equivalent) from waste according to the national inventory report submitted by Turkey in

2017 under the Framework Convention on Climate Change (Ağaçayak and Öztürk, 2017).

According to TURKSTAT 2020 greenhouse gas inventory results, total greenhouse gas emissions were calculated as 523.9 $MtCO_2$ equivalent with an increase of 3.1% compared to the previous year, and total greenhouse gas emissions per capita were 4 tons of CO_2 equivalent in 1990 and 6 tons in 2019, 2 tons of CO_2 equivalent in 1990 and 6.3 tons of CO_2 equivalent in 2020, and greenhouse gas emissions in the agriculture sector were calculated as 73.2 $MtCO_2$ equivalent in 2020, increasing by 58.8% compared to 1990 and 7.5% compared to the previous year (TURKSTAT, 2020).

Natural disasters such as changes in precipitation regime, temperature increases, desertification as a result of drought, floods and storms due to climate change threaten agricultural production efficiency, ecosystem and indirect economy at a significant level (Hayaloğlu, 2018). Turkey is one of the countries most vulnerable to the impacts of climatic change. According to the International Panel on Climate Change (IPCC, 2013), Turkey is expected to have a drier and warmer climate in the coming decades, as well as a more uncertain climate structure in terms of precipitation. Since Turkey, with its existing agro-ecosystems, is being negatively affected by climatic changes to a great extent, it is not possible to achieve sustainable development without eliminating the causes of these changes (Smagulova et al., 2017; Aydın and Aktuz, 2023).

According to the International Panel on Climate Change report, 95% of climate change is human-induced and therefore, greenhouse gas emissions should be reduced to take measures to prevent the negative effects of climate change (IPCC, 2013). All countries must make high-level investments to reduce greenhouse gas emissions (Aydın, 2023). Öztürk and Vulkan (2017) emphasize that the use of fuel and engine oil as energy sources in agricultural production, the incompatibility of the power balance of tractors and agricultural machinery, and the use of overloaded engines result in the release of smoke, toxic and harmful substances into the atmosphere with exhaust gas emissions, and in this respect, it is necessary to reduce greenhouse gas emissions that cause global warming for safe and healthy food production.

For sustainable agriculture, using energy more effectively in all production periods, reducing fossil fuel consumption, consuming this type of fuel at a minimum level, reducing greenhouse gas emissions and developing more effective agricultural systems (Öztürk, 2017). For this purpose, although many provincial, regional and national studies are being carried out to control and minimize the increase in greenhouse gas emissions, these studies should be increased (Gołasa et al., 2021). Studies and possible new studies in this direction are of great importance in terms of determining emissions by IPCC methods for the province, region and country in general and making accurate predictions for the future.

Çukurova region has a very important place in Turkey in terms of agricultural production. Ecologically, more tractors and agricultural machinery are also needed at the point where many crops can be produced in every period. In their study, Gül et al. (2022) examined the changes in the number of tillage tools and machines and sowing machines, number of tractors, agricultural mechanization level (kW, kW ha^{-1}, tractor 1000 ha^{-1}, ha $tractor^{-1}$) of Adana and Mersin provinces within the TR62 Region for the years 2013-2022 and made projection estimates for the years 2023-2032 by chain index method. As a result of the study, they emphasized that the number and power of tractors will increase for Adana and Mersin provinces within the TR62 Region, and the mechanization level criteria will also increase.

Recently, the studies on the determination of greenhouse gas emissions occurring in the production of different crops in many provinces, regions and countries (Bilgili et al. (2018) for olive production in the Eastern Mediterranean Region, Kuzu et al. (2024) for wheat and corn production in the Eastern Mediterranean Region, Küsek (2018) for lentil production in the Southeastern Anatolia Region, (Öztürk and Vulkan, 2017) for wheat and corn at the Turkish scale, (Öztürk et al. (2017) for cotton production at the Turkish scale, etc.) have been carried out. In addition, the precautions and new plans to be taken for the results of these studies have also been emphasized. In this study, it was aimed to determine the carbon dioxide emission values based on fossil fuel consumption in wheat and corn production, which are intensively produced in TR62 Region, and it tried to make estimates of emission projections for the coming years.

2. Material and Method

TR62 Region includes Adana and Mersin provinces. Adana province is located on both sides of the Seyhan River at latitude 35 north and longitude 34°-36° east. Mersin province is between 36-37° north latitude and 33-35° east longitude. While 30% of Turkey's land is agricultural, 38% of Adana's and 25% of Mersin's land is agricultural.

Figure 1. Location of TR62 Region on the map of Türkiye.
Şekil 1. *Türkiye haritasındaki Tr62 Bölgesinin konumu.*

TR62 region is a region where the use of tractors and agricultural machinery is intensive in the agricultural sector and can easily adapt to new technologies with its fertile soils (Anonymous, 2017). The location of TR62 Region on the map of Türkiye are given in Figure 1.

The total agricultural areas in TR62 Region are 831 965 ha. Adana province of the TR62 Region is the province where wheat, which accounts for 69% of Turkey's cereal cultivation area and ranks first, is harvested the earliest. Adana province accounts for approximately 5% of Turkey's wheat production and 17.5% of total corn production, according to 2023 statistics (Anonim, 2024). In 2020, 234 835 tons of wheat and 89 705 tons of corn were harvested from 85 571 ha of wheat and 8217 ha of corn cultivation areas in Mersin province within the TR62 Region (TURKSTAT, 2020).

The cultivated area, production amount and yield values for the main crops wheat and corn production for the TR62 Region between 2014 and 2023 years are taken from the Turkish Statistical Institute (TURKSTAT) agricultural statistics (TURKSTAT, 2024) and given in Table 1 and Table 2.

There was a 35.28% decrease in wheat cultivated areas and a 27.98% decrease in the amount of production, while an increase of 11.27% was recorded in yield values between 2014 and 2023 years (Table 1).

The decreases of 7.26%, 9.19% and 2.08% were recorded in corn cultivated areas, production amounts and yield values between 2014 and 2023 years, respectively, according to Table 2.

Kuzu et al. (2024) explained that the fuel values consumed per unit area for wheat and corn were used in

Table 1. Wheat cultivated area, amount of product produced and product yield values in TR62 Region (TURKSTAT, 2024).
Çizelge 1. *TR62 Bölgesindeki buğday ekili alanı, üretilen ürün miktarı ve ürün verim değerleri (TÜİK, 2024).*

Year	Cultivated area (ha)	Crop production (ton)	Yield (ton ha^{-1})
2014	321 890	833 739	2.59
2015	301 138	1 002 320	3.33
2016	285 042	855 883	3.00
2017	275 467	926 480	3.36
2018	265 202	915 240	3.45
2019	217 828	722 292	3.32
2020	244 274	856 684	3.51
2021	236 326	932 600	3.95
2022	214 729	739 371	3.44
2023	208 336	600 447	2.88
Mean	***257 023***	***838 506***	***3.28***

Table 2. Corn cultivated area, amount of product produced and product yield values in TR62 Region (TURKSTAT, 2024).
Çizelge 2. *TR62 Bölgesindeki mısır ekili alanı, üretilen ürün miktarı ve ürün verim değerleri (TÜİK, 2024).*

Year	Cultivated area (ha)	Crop production (ton)	Yield (ton ha^{-1})
2014	110 658	1 241 290	11.22
2015	114 121	1 215 688	10.65
2016	115 755	1 307 130	11.29
2017	111 115	1 236 917	11.13
2018	87 250	995 804	11.41
2019	75 751	809 566	10.69
2020	78 372	909 683	11.61
2021	78 193	922 639	11.80
2022	96 996	988 970	10.20
2023	102 624	1 127 193	10.98
Mean	**97 084**	**1 075 490**	11.22

carbon dioxide emission calculations as 115.16 l ha^{-1} and 133.17 l ha^{-1}, respectively, for the fuel consumption values for wheat and corn production in TR62 Region. The oil consumption values for wheat and corn production in TR62 Region were calculated as 4.5% of total fuel consumption and the total amount of oil consumed for wheat and corn production was determined as 5.18 l ha^{-1} and 5.99 l ha^{-1}, respectively (Hacıoğlu et al., 2024).

The heating values and CO_2 emission factors of fuel and oil used in wheat and corn production for TR62 Region are given in Table 3 (IPCC, 1996; Öztürk et al., 2017; Bilgili and Aybek, 2018; Küsek, 2018).

The calculations of total CO_2 emissions from fuel and oil as described in the Intergovernmental Panel on Climate Change (IPCC, 1996) were taken into consideration, while calculating the CO_2 emissions from fossil (fuel and oil) sources for wheat and corn production in TR62 Region, (Öztürk et al., 2017; Bilgili and Aybek 2018; Küsek, 2018). The equations used in the calculation of CO_2 emissions based on fossil fuel and oil consumption are given in Table 3 and Table 4.

Table 3. The heating values and CO_2 emission factors of diesel fuel and engine oil used in wheat and corn production in TR62 Region.

Çizelge 3. *TR62 Bölgesindeki buğday ve mısır üretiminde tüketilen dizel yakıt ve kullanılan motor yağının ısıl değerleri ve CO_2 emisyon faktörleri.*

Fuel	Fuel heating value *(GJ l^{-1})*	CO_2 emission factor *(kg_{CO2} GJ^{-1})*
Diesel	0.0371	74.01
Engine oil	0.0382	73.28

Table 4. Equations used in the calculations for the determination of CO_2 emissions from fossil (fuel and oil) sources ((IPCC, 1996).

Çizelge 4. *Fosil (yakıt ve yağ) kaynaklı meydana gelen CO_2 emisyonlarının tespitine ait yapılan hesaplamalarda kullanılan eşitlikler ((IPCC, 1996).*

ToE= FCE + OCE [(Total CO_2 emissions = CO_2 emissions from fuel + CO_2 emissions from oil use)]
FCE= TD x FHV x FE [(Fuel-based CO_2 emissions ($kgCO_2$) = Total amount of diesel consumed (l) x Fuel lower heating value (0.0371 GJ l^{-1}) x Fuel emission factor (74.01 kg CO_2 G J^{-1})]
OCE= TO x OHV x OE [CO_2 emissions from oil use (kg CO_2) = Total amount of oil consumed (l) x Oil lower heating value (0.0382 GJ l^{-1}) x Oil emission factor (73.28 kg CO_2 G J^{-1})]

The following equations were used for specific fuel consumption (fuel consumption per amount of production) and specific CO_2 emissions (CO_2 emissions per amount of production) in determining crop-based fuel consumption and crop-based CO_2 emissions for wheat and corn production for the TR62 Region (Öztürk et al., 2017; Bilgili and Aybek 2018; Küsek, 2018). The density value of diesel fuel was taken into account as 0.84 g cm^{-3}, when converting the total amount of fuel consumed into grams (Beşergil, 2009).

$$SFC=ToE/CP \quad (1)$$

Where;
SFC : Specific fuel consumption (g_{fuel} $kg_{product}^{-1}$),
ToE : Amount of fuel consumed (g_{fuel})
CP : Amount of production ($kg_{product}^{-1}$).

$$SCE=ToE/CP \quad (2)$$

Where;
SCE : Specific CO_2 emission (gCO_2 $kg_{product}^{-1}$),
ToE : Total CO_2 emissions (gCO_2),
CP : Amount of production ($kg_{product}^{-1}$).

The increase and decrease of values for total CO_2 emission (ToE), specific fuel consumption (SFC) and specific CO_2 emission (SCE) were calculated as percentages and the average coefficients of the percentages were obtained in wheat and maize production in TR62 Region between 2014 and 2023 years. A positive (+) projection coefficient indicates that the values for total CO_2 emission (ToE), specific fuel consumption (SFC) and specific CO_2 emission (SCE) have increased, while a negative (-) coefficient indicates that the ToE, SFC and SCE have decreased (Demir et al., 2013).

Calculations for the rate of change for the sample two years can be formulated as follows:

$$CR= [(Y_1 - Y_0) / Y_0] * 100 \quad (3)$$

Where:
CR: Rate of change (%) for the two sample years
Y_1= Values for ToE, SFC and SCE in the current year
Y_0= Values for ToE, SFC and SCE in the previous year

The values for ToE, SFC and SCE in the previous year was multiplied by the coefficient related to this ToE, SFC and SCE values, and in line with the decrease and increase of the coefficients, the 10-year projections of the ToE, SFC and SCE in wheat and corn production for the TR62 Region until 2033 were determined (Demir et al., 2013; Altuntaş, 2020).

3. Results and Discussion

Total CO_2 emissions, specific fuel consumption and specific CO_2 emissions calculated based on greenhouse gas emissions for TR62 Region are affected by wheat and corn production area, total production amount and yield values of the Region (Table 1 and Table 2). Accordingly, the changes in the cultivated area, production amount and yield values for the years 2014-2023 in wheat and corn production for the TR62 Region are given in Figure 2 and Figure 3.

Figure 2. Changes in wheat production values for TR62 Region by years.
Şekil 2. *TR62 Bölgesi için buğday üretim değerlerindeki yıllara göre değişim.*

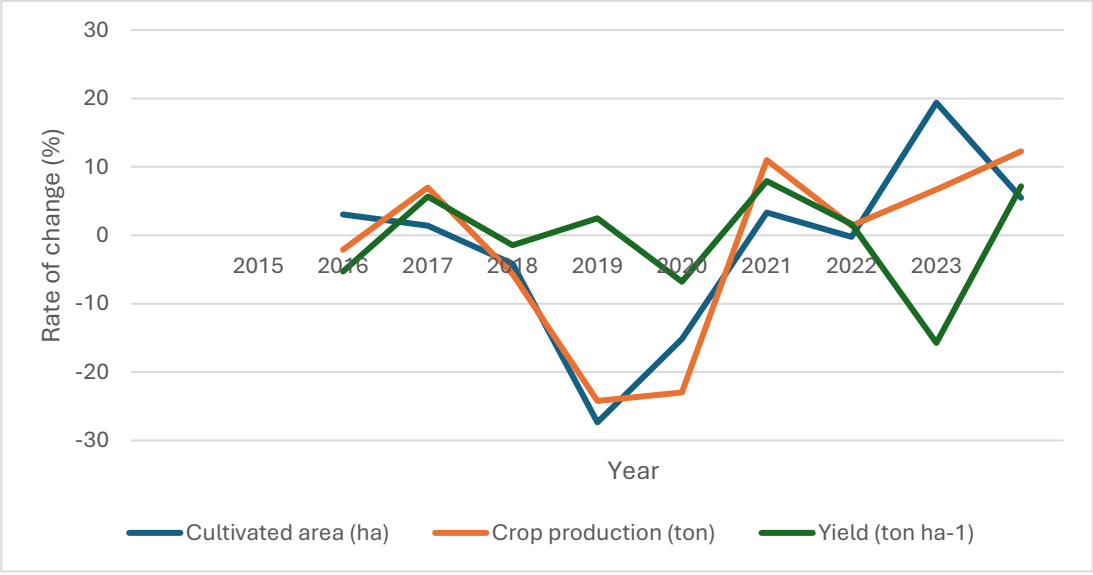

Figure 3. Changes in corn production values for TR62 Region by years.
Şekil 3. *TR62 Bölgesi için mısır üretim değerlerindeki yıllara göre değişim.*

The average values of total CO_2 emission (ToE), specific fuel consumption (SFC) and specific CO_2 emission (SCE) calculated in wheat production in TR62 Region for the last 10 years between 2014 and 2023 years are given in Table 5.

The average total CO_2 emission from fossil fuel (diesel+oil) in wheat production between 2014 and 2023 years was 87.19 $ktCO_2$, the average specific fuel consumption was 30.80 g_{fuel} $kg_{product}^{-1}$ and the average specific CO_2 emission was 105.29 gCO_2 $kg_{product}^{-1}$ for the TR62 Region, (Table 5).

According to Table 6, while there is a 7.25% decrease in total CO_2 emissions in corn production between 2014 and 2023, there is a 9.73% and 9.01%

increase for specific fuel consumption and specific CO_2 emissions, respectively. Figure 4 shows the change in total CO_2 emissions and specific CO_2 emissions for the previous year in wheat production for TR62 Region between 2014 and 2023 years.

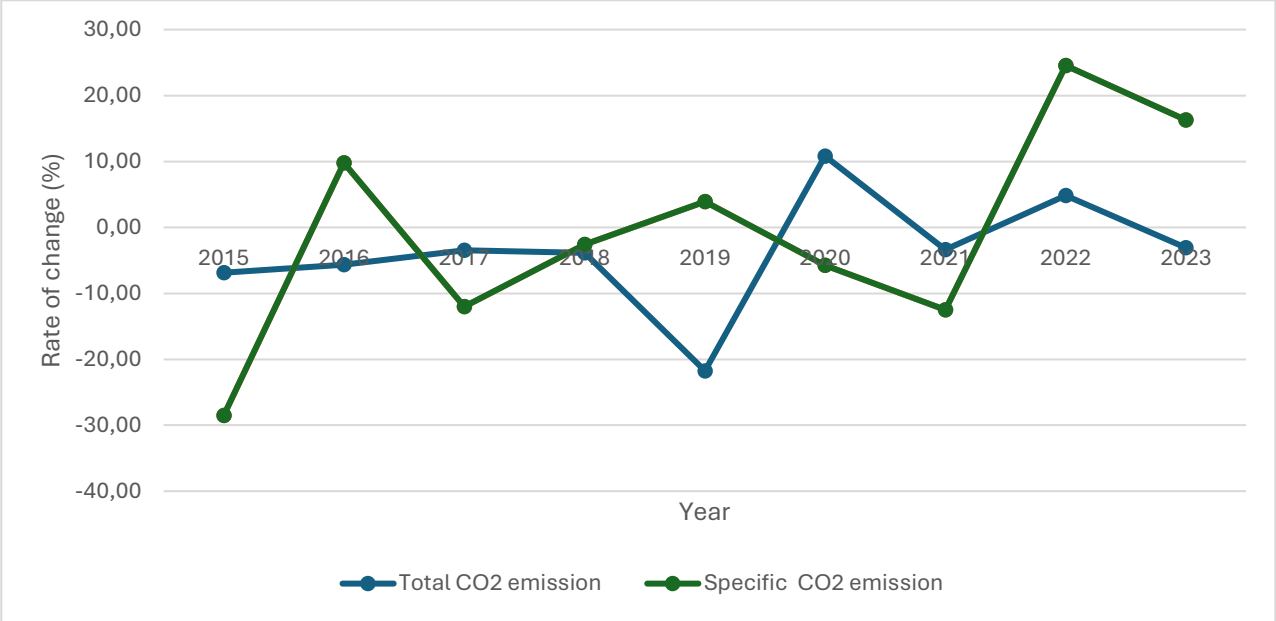

Figure 4. Changes in the values of total CO_2 emissions and specific CO_2 emissions in wheat production for TR62 Region by years.
Şekil 4. *TR62 Bölgesi için buğday üretimindeki toplam CO_2 emisyonu ve özgül CO_2 emisyonunun değerlerindeki yıllara göre değişim.*

Table 5. Changes in total CO_2 emissions, specific fuel consumption and specific CO_2 emissions in wheat production for TR62 Region between 2014 and 2023 years.
Çizelge 5. *TR62 Bölgesi için buğday üretiminde 2014-2023 yılları arasındaki toplam CO_2 emisyonu, özgül yakıt tüketimi ve özgül CO_2 emisyonunun değişimi.*

Year	ToE (Total CO_2 emissions, $ktCO_2$)	SFC (Specific fuel consumption, (g_{fuel} $kg_{product}^{-1}$)	SCE (Specific CO_2 emission (gCO_2 $kg_{product}^{-1}$)
2014	106.45	37.35	127.68
2015	99.59	29.06	99.36
2016	94.27	32.22	110.14
2017	91.10	28.76	98.33
2018	87.70	28.03	95.83
2019	72.04	29.17	99.73
2020	80.78	27.58	94.30
2021	78.16	24.51	83.80
2022	82.12	32.49	111.07
2023	79.67	38.81	132.69
Mean	***87.19***	***30.80***	***105.29***

Table 6. Changes in total CO_2 emissions, specific fuel consumption and specific CO_2 emissions in corn production for TR62 Region between 2014 and 2023 years.
Çizelge 6. *TR62 Bölgesi için mısır üretiminde 2014-2023 yılları arasındaki toplam CO_2 emisyonu, özgül yakıt tüketimi ve özgül CO_2 emisyonunun değişimi.*

Year	ToE (Total CO_2 emissions, $ktCO_2$)	SFC (Specific fuel consumption, (g_{fuel} $kg_{product}^{-1}$)	SCE (Specific CO_2 emission (gCO_2 $kg_{product}^{-1}$)
2014	42.32	9.97	34.09
2015	43.64	10.50	35.90
2016	44.27	9.91	33.87
2017	42.49	10.05	34.35
2018	33.37	9.80	33.51
2019	28.97	10.47	35.78
2020	29.97	9.64	32.95
2021	29.90	9.48	32.41
2022	37.09	10.97	37.51
2023	39.25	10.18	34.82
Mean	***37.13***	***10.10***	***34.52***

The average total CO_2 emission from fossil fuel (diesel+oil) of corn production was determined as 37.13 $ktCO_2$, the average specific fuel consumption as 10.10 g_{fuel} $kg_{product}^{-1}$ and the average specific CO_2 emission as 34.52 gCO_2 $kg_{product}^{-1}$ between 2014 and 2023 years for the TR62 Region (Table 6). According to Table 6, there is a 2.13% increase in both specific fuel consumption and specific CO_2 emissions while there is a 7.26% decrease in total CO_2 emissions in corn production between 2014 and 2023 years.

Figure 5 shows the change in total CO_2 emissions and specific CO_2 emissions for the previous year between 2014 and 2023 years in corn production for TR62 Region. The lowest total CO_2 emission in the last 10 years was 72.04 kt CO_2 in 2019, the lowest specific fuel consumption was 24.51 g_{fuel} $kg_{product}^{-1}$ in 2021 and

the lowest specific CO_2 emission was 83.80 gCO_2 $kg_{product}^{-1}$ in 2021 in wheat production for the TR62 Region. In wheat production for TR62 Region, the highest values of ToE, SFC, and SCE in the last 10 years were determined to be 106.45 $ktCO_2$ in 2014, 38.81 g_{fuel} $kg_{product}^{-1}$ in 2023, and 132.69 gCO_2 $kg_{product}^{-1}$ in 2023, respectively.

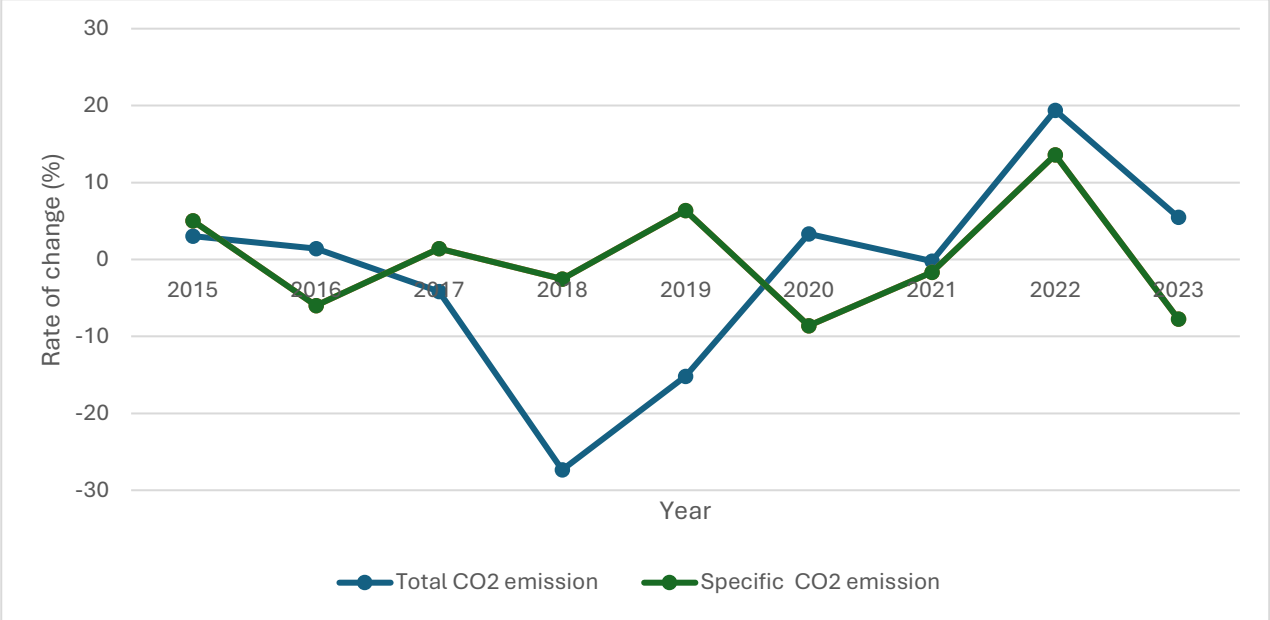

Figure 5. Changes in total CO_2 emission and specific CO_2 emission values in corn production for TR62 Region by years.
Şekil 5. *TR62 Bölgesi için mısır üretimindeki toplam CO_2 emisyonu ve özgül CO_2 emisyonunun değerlerindeki yıllara göre değişim.*

The lowest total CO_2 emission in the last 10 years was 28.97 $ktCO_2$ in 2019, the lowest specific fuel consumption was 9.48 g_{fuel} $kg_{product}^{-1}$ in 2021 and the lowest specific CO_2 emission was 32.41 gCO_2 $kg_{product}^{-1}$ in 2021 in corn production for the TR62 Region. the highest values of ToE, CVE, and CVE in the last 10 years were determined to be 44.27 $ktCO_2$ in 2016, 10.97 g_{fuel} $kg_{product}^{-1}$ in 2022, and 37.51 gCO_2 $kg_{product}^{-1}$ in 2022, respectively, in corn production for TR62 Region.

It is seen that specific CO_2 emission increases as wheat and corn production amounts decrease when specific CO_2 emission and wheat and corn production amounts are evaluated together.

Kuzu et al. (2024) reported that the averages of CO_2 emission values, specific fuel consumption and specific CO_2 emission values for wheat production in the Eastern Mediterranean Region for the years 2018-2022 were 154.50 $ktCO_2$, 26.60 g_{fuel} $kg_{product}^{-1}$ and 90.49 gCO_2 $kg_{product}^{-1}$, respectively, while the averages of CO_2 emission, specific fuel consumption and specific CO_2 emission values for wheat production in the TR62 Region for the years 2014-2023 were 87. 13 $ktCO_2$, 30.80 g_{fuel} $kg_{product}^{-1}$ and 105.29 gCO_2 $kg_{product}^{-1}$, respectively, and the values found in the TR62 Region were 77.33% lower than the Eastern Mediterranean Region, while the specific fuel consumption and specific CO_2 emissions gave similar values according to the total CO_2 emission values. Öztürk and Vulkan (2017) reported that the average CO2 emission in wheat production was 1.4 $MtCO_2$ $_{year}^{-1}$, specific fuel consumption was 20.7 g_{fuel} $kg_{product}^{-1}$ and specific CO_2 emission was 67.7 g_{CO2} $kg_{product}^{-1}$ in wheat production between 2010 and 2015 years for Turkey as a whole.

Projection estimates between 2024 and 2033 years are given in Table 7 and Table 8 by calculating the projections between 2024 and 2033 years by taking into account the values of ToE, SFC and SCE between 2014 and 2023 years in wheat and corn production for TR62 Region.

When the projection coefficients obtained according to the rates of change in the past years for the years 2024-2033 considering the CO_2 emission values, specific fuel consumption and specific CO_2 emission values between 2014 and 2023 years in wheat production for TR62 Region are examined, it is seen that it is -2.862 for ToE and 1.656 for the parameters SFC and SCE (Table 7).

It is estimated that as a parameter in the coming years, total CO_2 emissions will show a decrease, while

specific fuel consumption and specific CO_2 emission values will show a loss of increase. The ToE, SFC and SCE values produced for the TR62 Region in 2033 are predicted to be 38.80 $ktCO_2$, 106.94 g_{fuel} $kg_{product}^{-1}$ and 365.60 gCO_2 $kg_{product}^{-1}$, respectively.

It is estimated that total CO_2 emission will show a decreasing trend, while specific fuel consumption and specific CO_2 emission values will show an increasing trend for each parameter in the coming years. In 2033, it is predicted that ToE, SFC and SCE values for wheat production for TR62 Region will be 59.59 $ktCO_2$, 45.74 g_{fuel} $kg_{product}^{-1}$ and 156.37 gCO_2 $kg_{product}^{-1}$, respectively.

Table 7. Projection estimates of wheat production in TR62 Region for the years 2024-2033 based on ToE, SFC and SCE values for the years 2014-2023.
Çizelge 7. *TR62 Bölgesi için buğday üretiminde 2014-2023 yıllarına ait ToE, ÖzY ve ÖzE değerleri dikkate alınarak 2024- 2033 yıllarına ait projeksiyon tahminleri.*

Year	**ToE** (Total CO_2 emissions, $ktCO_2$)	**SFC** (Specific fuel consumption, (g_{fuel} $kg_{product}^{-1}$)	**SCE** (Specific CO2 emission (gCO_2 $kg_{product}^{-1}$)
2014	106.45	37.35	127.68
2015	99.59	29.06	99.36
2016	94.27	32.22	110.14
2017	91.10	28.76	98.33
2018	87.70	28.03	95.83
2019	72.04	29.17	99.73
2020	80.78	27.58	94.30
2021	78.16	24.51	83.80
2022	82.12	32.49	111.07
2023	79.67	38.81	132.69
Projection coefficient	-2.862	1.656	1.656
2024	77.39	39.46	134.89
2025	75.18	40.11	137.12
2026	73.03	40.77	139.39
2027	70.94	41.45	141.70
2028	68.91	42.13	144.05
2029	66.93	42.83	146.43
2030	65.02	43.54	148.86
2031	63.16	44.26	151.32
2032	61.35	44.99	153.83
2033	59.59	45.74	156.37

Table 8. Projection estimates for corn production in TR62 Region for the years 2024-2033, taking into account the values of ToE, SFC and SCE for the years 2014-2023.
Çizelge 8. *TR62 Bölgesi için mısır üretiminde 2014-2023 yıllarına ait ToE, ÖzY ve ÖzE değerleri dikkate alınarak 2024- 2033 yıllarına ait projeksiyon tahminleri.*

Year	**ToE** (Total CO_2 emissions, $ktCO_2$)	**SFC** (Specific fuel consumption, (g_{fuel} $kg_{product}^{-1}$)	**SCE** (Specific CO2 emission (gCO_2 $kg_{product}^{-1}$)
2014	42.32	9.97	34.09
2015	43.64	10.50	35.90
2016	44.27	9.91	33.87
2017	42.49	10.05	34.35
2018	33.37	9.80	33.51
2019	28.97	10.47	35.78
2020	29.97	9.64	32.95
2021	29.90	9.48	32.41
2022	37.09	10.97	37.51
2023	39.25	10.18	34.82
Projection coefficent	-0.114	0.490	0.490
2024	39.20	10.23	34.99
2025	39.16	10.28	35.16
2026	39.11	10.33	35.33
2027	39.07	10.39	35.50
2028	39.02	10.44	35.68
2029	38.98	10.49	35.85
2030	38.94	10.54	36.03
2031	38.89	10.59	36.20
2032	38.85	10.64	36.38
2033	38.80	10.69	36.56

In Table 8, corn product production for the TR62 Region, CO_2 emission values, specific fuel consumption and specific CO_2 emission values for the years 2014-2023 are recorded. Emission coefficients obtained according to the change rates compared to previous years for the years 2024-2033, -0.114 for ToE, SFC and SCE was found to be 0.490.

It is estimated that as a parameter in the coming years, total CO_2 emissions will show a decrease, while specific fuel consumption and specific CO_2 emission values will show a loss of increase. The ToE, SFC and SCE values produced for the TR62 Region in 2033 are predicted to be 38.80 $ktCO_2$, 10.69 g_{fuel} $kg_{product}^{-1}$ and 36.56 gCO_2 $kg_{product}^{-1}$, respectively.

4. Conclusion

It was determined that the emissions of wheat and corn production in the TR62 Region were based on fossil fuel consumption. it is seen that specific CO_2 emissions are observed as the wheat and corn production amounts decrease when the specific CO_2 emission and wheat and corn production amounts are evaluated together and the changes over the years are examined.

ToE, SFC and SCE values of wheat and corn production for the TR62 Region between 2014 and 2023 years are recorded and the projections between 2024 and 2033 are produced. total CO_2 emission decreases and specific fuel consumption and specific CO_2 values increase as each parameter. It is expected to be recorded, according to the future years.

It is possible to reduce fossil fuel consumption by using energy more efficiently in all production periods for sustainable agriculture. Minimal consumption of fossil fuels will lead to a reduction in greenhouse gas emissions and the development of more efficient sustainable agricultural systems. The practices related to the use of protected tillage systems and increasing parcel sizes instead of conventional tillage systems in agricultural production, which cause the highest fuel consumption; limiting the use of chemical fertilizers and pesticide inputs required for crop production will ensure more efficient use and reduce greenhouse gas emissions. In addition, reducing the inputs of tractors and agricultural machinery in the production system, selecting the tractor and agricultural tools and machinery in harmony with the tractor and agricultural machinery at the point of ensuring power and machine harmony, and using the engine at optimal load will reduce the release of smoke, toxic and harmful substances into the atmosphere in exhaust emissions. Appropriate matching of agricultural field size and machine field capacity, new environmentally friendly production planning and switching from conventional tillage to conservation tillage will reduce fossil fuel consumption and improve the environmental profile.

In this context, it is important that the Organizations of the Ministry of Agriculture and Forestry, Universities and Farmers' Associations, under a common roof, carry out more serious studies and planning to increase production and quality and to take the mentioned measures to reduce carbon dioxide emissions under a common roof in order to reduce fuel consumption in fossil fuel-based production of CO_2 emissions on a provincial, regional, regional and national basis.

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