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Research Article

Estimating the carbon footprint of dairy cattle in the district of Karapınar, in the province of Konya

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ABSTRACT

Global warming refers to the increase in the amount of heat resulting from the release of greenhouse gases into the atmosphere. One of the prominent strategies to mitigate global warming in the face of an increasing world population is to regulate the livestock sector. The effect of cattle on global warming is through the release of greenhouse gases (CO2, CH4). The carbon footprint can be defined as the damage caused to the environment by the amount of greenhouse gases in the form of carbon dioxide resulting from the activities of living beings. One of the places where dairy farming is performed intensively in Türkiye is the district of Karapınar in the province of Konya. According to the data from the Turkish Statistical Institute, the total number of dairy cattle in the district of Karapınar was 28,186 heads in 2018 and 32,405 heads in 2019. The difference of 4,219 heads is estimated to raise the carbon footprint potential by 426.4 kg CO2e year-1 in 2019 compared to 2018. When the increase per animal was calculated, the result was 0.01 kg CO2e year-1. This calculation was made utilising the Tier-1 method, using the equations provided in the Intergovernmental Panel on Climate Change (IPCC) 2006 guide. In the guide, the methods Tier-2 and Tier-3 are also specified, and more detailed methods are planned for future studies.

INTRODUCTION

It is stated that the world population reached approximately 8 billion people in 2023. According to the United Nations, this increasing number is expected to reach 9.7 billion in 2050 and 10.4 billion in 2100. According to the data from the Turkish Statistical Institute (TUIK), Türkiye's population reached 85.2 million in 2023, ranking 18th in the world. This number is estimated to reach 93 million in 2050.

The increasing population also increases the need for food for the continuity of life. In order to meet the increasing food demand, new techniques in agriculture and animal husbandry must become widespread, and the number of products produced per unit area must increase (Kitani, 1999; Özpınar, 2023). For this reason, there has been an increase in the use of intensive farming methods for dairy farming. Increasing the production in dairy farming can be achieved by improving the productivity of animals or by increasing the number of animals. As a result of the activities carried out to achieve the mentioned increases, the emission of greenhouse gases into the atmosphere is increasing. With the increase in the concentrations of gases released into the atmosphere, an increase in the earth's temperature, referred to as "global warming", is observed (Köknaroğlu and Akünal, 2010). While Bayraç (2010) defines global warming as a systematic increase in the temperature worldwide, Doğan et al. (2010) define it as the increase in the temperature on the earth due to the increase in gas concentrations in the atmosphere.

As a result of the increase in the number of dairy animals and various activities carried out to enhance productivity, the amount of greenhouse gases released into the atmosphere will also increase. The term carbon footprint is used to track the outputs of these activities at the production and consumption stages. The increase in greenhouse gases in the atmosphere due to livestock farming is caused by the effect of carbon dioxide (CO_2) and methane (CH_4) gases (Türkeş, 2000). 35-40% of worldwide methane emissions originate from enteric fermentation and manure management in livestock (Steinfeld et al., 2006). It is stated that approximately 65% of the total emissions of greenhouse gases resulting from livestock activities are caused by cattle. In most developing countries such as Türkiye, 39% of greenhouse gas emissions from the livestock sector originate from enteric fermentation and 26% from manure management (Herrero et al., 2013). This reveals that most of the greenhouse gases released from activities in the livestock sector originate from cattle (Koyuncu and Akgün, 2017).

Cattle have a unique digestive system compared to other animals, allowing them to digest materials rich in poor-quality cellulose. As a result of this digestion, they have an important place in the production of methane and greenhouse gases. While it can be seen that cattle, when considered individually, produce a small amount of methane gas (80-110 kg year^{-1}), this amount is quite high when considering the cattle population (Koyuncu and Akgün, 2017). Greenhouse gases resulting from milk production in cattle account for approximately 20% of the total emissions (Gerber et al., 2013). 2-12% of the gross energy ingested with the diet is lost by being converted into methane (CH_4) during microbial digestion in the rumen. This

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induces a negative impact on global warming (Öztürk, 2007). It is also stated that the energy required to produce feed raw materials constitutes approximately 10% of the total carbon dioxide emissions, and the effect of the amount of energy consumed for milk production on emissions is considered insignificant (Koyuncu and Akgün, 2017). Among the greenhouse gases that cause global warming, methane gas (CH_4) ranks second after carbon dioxide (CO_2) (Çetin et al., 2020). However, it is also stated that the global warming potential of methane might be 21 times that of carbon dioxide over a period of approximately 100 years (Köknaroğlu and Akünal, 2010).

The concept of carbon footprint in global warming is used to indicate the impact of the activities performed to meet the needs of living beings. Different methods are used to measure this impact, and online programs are even designed to calculate the results (Güven ve İlker, 2016).

In light of this information, the study aimed to evaluate the impact of dairy cattle on global warming in the district of Karapınar, located in the province of Konya, an important location for dairy farming. Both carbon dioxide and methane gases were focused on in order to calculate this effect.

MATERIALS and METHODS

Karapınar, the region chosen to conduct the research, is a district of the province of Konya, one of the prominent provinces in Türkiye regarding dairy cattle breeding. According to TUIK data, Karapınar district ranked first among the districts of Konya in 2018 and second in 2019 regarding the number of dairy cattle. Among the dairy cattle bred in the district, the number of milking animals was 28,186 heads in 2018 and 32,405 in 2019 (TUIK, 2023). The carbon footprint of dairy cattle in the Karapınar district was calculated by matching the data received from TUIK with the calculation tables in the Intergovernmental Panel on Climate Change (IPCC, 2006) guide. For the values to be used in the calculations to be made in the study, Türkiye was classified as part of the "Eastern Europe" region in the tables specified in the IPCC guide. No living or non-living animal material was used within the scope of the study.

Calculation of the carbon footprint

Tier (Tier 1, Tier 2, Tier 3) methods determined by the IPCC are used to calculate carbon footprints. The Tier 1 method was selected due to its ease of use. This method works based on prediction (IPCC, 2006). Emission factor values in the IPCC guide are organised based on animal species and climate zones (temperatures). In the IPCC guide (IPCC, 2006), equation 10.22 was used to calculate the carbon footprint resulting from manure management (Equation 1).

$$CH_{4(manure)} = \sum_{(T)} \frac{EF_{(T)} \times N_{(T)}}{10^6}$$

(Eq. 1)

In this equation, $CH_{4(Manure)}$ refers to methane emissions from manure management (Gg CH_4 $year^{-1}$), $EF_{(T)}$ is the defined emission factor for the livestock sector (kg CH_4 $head^{-1}$ $year^{-1}$), $N_{(T)}$ is the total number of animals (head) in the population, T is the animal species or category.

For the $EF_{(T)}$ value in the equation, the values from Table 10.14 of the IPCC (IPCC, 2006) guide (Table 1) were used. In the related table, the levels of development of the countries, differences in manure management systems and temperature conditions of the region are taken into account. Türkiye has the status of a developing country. The average temperature for the district of Karapınar in the province of Konya in 2018 and 2019 was 11.1°C (MGM, 2023). The values provided in Table 10.14 of the IPCC (IPCC, 2006) guide will be used for the calculations and are given in Table 1.

Table 1. Methane emission factor from manure management for cattle according to temperature (IPCC, 2006)

	Cold					Mild											Hot		
	≤10°C	11°C	12°C	13°C	14°C	15°C	16°C	17°C	18°C	19°C	20°C	21°C	22°C	23°C	24°C	25°C	26°C	27°C	≥28°C
Dairy cattle	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Other cattle	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Manure-derived methane emission factors that should be obtained according to annual average temperatures

The methane gas emission factor resulting from manure management was selected from the values in Table 1. Since the average temperature of Karapınar in 2018 and 2019 was 11.1°C, and based on the 11°C value in the table, the methane emission factor resulting from manure management for dairy cattle will be 2 kg CH_4 $head^{-1}$ per year.

The Tier 1 method in the IPCC (IPCC, 2006) guide is a simplified method used for estimating emissions by selecting emission values according to animal species and subcategories, feeding patterns and annual average milk yield. The IPCC (IPCC, 2006) guide states that Equation 10.19 (Equation 2) should be used to calculate CH_4 emissions from enteric fermentation.

$$\text{Emissions} = EF_{(T)} \times \frac{N_{(T)}}{10^6}$$

(Eq. 2)

In this equation, emissions refers to the methane emissions from enteric fermentation (10^3 tonne CH_4 $year^{-1}$), $EF_{(T)}$ refers to the emission factor defined for livestock sectors (kg CH_4 $head^{-1}$ $year^{-1}$), $N_{(T)}$ refers to total number of animals in the population, T refers to the animal species.

For the $EF_{(T)}$ value in the concerning equation, the emission factor used was specified in Table 10.11 within the subcategories of the IPCC (IPCC, 2006) guide. In this table, enteric fermentation emission factor values originating from cattle calculated by the Tier 1 method are evaluated, as well as the status of development of the countries, differences in feed composition and annual milk amount (head) (Table 2). In this table, since Türkiye is located in Eastern Europe, the value taken as a basis for dairy cattle is 99 (the annual milk yield of the cows selected is 2550 kg head^{-1}). In the case that the annual milk yield does not meet the specified value in the country category, the corresponding emission factor should be selected. For example, if the annual milk yield is 2000 kg head^{-1}, 90 should be selected as the emission factor value for dairy cattle.

For the year 2019; $CH_{4(manure)} = \sum(T) \frac{2x\ 32405}{10^6}$

- According to Equation 2, methane emission values from enteric fermentation were 2.790 Gg CH_4 year^{-1} for 2018 and 3.208 Gg CH_4 year^{-1} for 2019. The increase in one year was 0.418 Gg CH_4 year^{-1}.

For the year 2018; $Emissions = 99\ x\ \frac{28186}{10^6}$

For the year 2019; $Emissions = 99\ x\ \frac{32405}{10^6}$

Table 2. Enteric fermentation emission factors for cattle according to the Tier 1 method (IPCC, 2006)

Region	Type of Cattle	Emission Factor (kg CH_4 head^{-1} year^{-1})	Explanation (Other)
North America	Dairy cattle	128	Annual milk production 8.400 kg head^{-1}
	Others	53	
West Europe	Dairy cattle	117	Annual milk production 6.000 kg head^{-1}
	Others	57	
East Europe	Dairy cattle	99	Annual milk production 2.550 kg head^{-1}
	Others	58	
Australia	Dairy cattle	90	Annual milk production 2.200 kg head^{-1}
	Others	60	
South America	Dairy cattle	72	Annual milk production 800 kg head^{-1}
	Others	56	
Asia	Dairy cattle	68	Annual milk production 1.650 kg head^{-1}
	Others	47	
Middle Asia/Africa	Dairy cattle	46	Annual milk production 500 kg head^{-1}
	Others	31	
India	Dairy cattle	58	Annual milk production 900 kg head^{-1}
	Others	27	

Emission factor values to be taken according to regions

In the IPCC (IPCC, 2006) guide, it is stated that, when converting methane emissions to a carbon footprint value as CO_2e, it should be multiplied by 25.

RESULTS

When the values corresponding to the formulas in the equations are inserted, the results are presented below and shown in Table 3.

- According to Equation 1, the manure-derived methane emission value found was 0.0564 Gg CH_4 year^{-1} for 2018, while it was 0.0648 Gg CH_4 year^{-1} for 2019. Methane emissions from manure increased in 2019 compared to 2018. The value of this increase is 0.008 Gg CH_4 year^{-1}.

For the year 2018; $CH_{4(manure)} = \sum(T) \frac{2x\ 28186}{10^6}$

In order to express methane emission values as global warming potential, it is stated that the value found for CO_2 equivalence is multiplied by 25 (IPCC, 2006; Crosson et al., 2011). The CO_2 equivalence of emission values are also given in Table 3. The CH_4 emission value per animal was 0.1 kg CH_4 head^{-1} in both years.

Ersoy (2017) calculated the greenhouse gas emission values of cattle in the province of Konya according to 2015 and found that the methane emission value from manure was 1560 tonnes CH_4 year^{-1}, the methane emission value from enteric fermentation was 70040 tonnes CH_4 year^{-1} and the total emission value was 71600 tonnes CH_4 year^{-1}. According to the findings of the study, methane emissions from enteric fermentation in the province of Konya constituted approximately 3.9% in 2018 and approximately 4.5% in 2019. Manure-derived methane emission values constituted approximately 3.62% in 2018 and 4.15%

Table 3. Enteric fermentation emission factors for cattle according to the Tier 1 method (IPCC, 2006)

Years	$CH_{4(manure)}$ (tonne CH_4 $year^{-1}$)	Emissions (tonne CH_4 $year^{-1}$)	CO_2e $year^{-1}$	
			$CH_{4(manure)}$	Emissions
2018	56,4	2790	1410	1743,75
2019	64,8	3208	1620	2005

Emission values and CO2e equivalents by year

in 2019. When Türkiye's ranking is observed in the respective study, the values of Aydın province, which ranks 16th, are approximately similar to those found for the district of Karapınar.

In the study conducted by Yaylı and Kılıç (2020) on dairy cattle farms, the enteric fermentation-derived methane emission value was found to be 659.3 Gg CH_4 $year^{-1}$ for Türkiye, 8.4 Gg CH_4 $year^{-1}$ for the province of Bursa, and manure-derived methane emission value was found to be 99.9 Gg CH_4 $year^{-1}$ for Türkiye and 1.7 Gg CH_4 $year^{-1}$ for Bursa province. The values found for Karapınar correspond to approximately 1/3 of those found for Bursa province. The enteric fermentation-derived methane emission value of Karapınar is approximately 2% of that of Türkiye, and the manure-derived methane emission value is approximately 1.66%.

Ceyhan et al. (2020), in their study in Niğde on 2000 heads of Awassi sheep, found that the CH_4 emission produced by enteric fermentation was 0.016 Gg CH_4 $year^{-1}$, while the CH_4 emission from manure was 0.0002 Gg CH_4 $year^{-1}$. Compared to the values we calculated for cattle, the values found for sheep are relatively low. This is due to the difference in $EF_{(I)}$ value. For sheep, this value is taken as 8 for enteric fermentation and 0.10 for methane emission from manure.

In their study, Kara et al. (2019) found that the CH_4 emission value per animal in autochthonous, imported and hybrid cattle breeds in Konya in 2017 was 21.6 kg The value per animal found in Karapınar in 2018 and 2019 were significantly lower than this value.

In some studies, it has been stated that the largest contribution to greenhouse gas emissions is CH_4 resulting from enteric fermentation (Robertson et al., 2015; Buratti et al., 2017; Kılıç and Amet, 2017; Kiggundu et al., 2019). In the calculated values, enteric fermentation accounted for approximately 55% of the total emissions in 2018, while it represented approximately 44% in 2019.

DISCUSSION

Agriculture and animal husbandry are the biggest sectors expected to be affected by climate change. There is an increasing need for food due to the rise in population. Animal products, which are essantial for maintaining a healthy lifestyle, are insufficient to meet the requirements. Therefore, increasing the production of animal products is possible through methods such as increasing the number of animals and improving productivity. There is a direct relationship between this situation and global warming, and an increase in greenhouse gas emissions is inevitable.

In the study, Tier 2 method is selected for the calculation of greenhouse gas emissions. This method provides more reliable results as it includes more comprehensive calculations compared to Tier 1. Reducing the emission of greenhouse gases is essential in the battle against climate change. Karapınar district is a prominent area not only in animal husbandry but also in the agricultural sector. In order to reduce greenhouse gas emissions caused by dairy cattle in the Karapınar district, farms should be provided with training on manure management and enteric fermentation. Breeders should be made aware of environmentally friendly practices. A correct plan should be created and implemented to address these issues. For example, arrangements should be made for feed rations, and support should be provided for the installation of biogas facilities.

CONCLUSION

As a result, a contribution has been made to the literature on carbon footprint, which is stated to have a significant impact on gases emitted from animals. In this context, the extent to which dairy cows affect the carbon footprint has been revealed. Some suggestions for reducing this effect have been presented, and a basis for future studies has been established. The number of studies on this subject in Türkiye is insufficient, and more research is needed. It is intended to establish a basis with this study, and it is also planned to use the Tier 2 method in future studies and to calculate the carbon footprint of dairy cattle nationwide.

DECLARATIONS

Conflict of Interest

The author declared that there is no conflict of interest.

Author contribution

Idea, concept and design: OE

Data collection and analysis: OE

Drafting of the manuscript: OE

Critical review: OE

Data Availability

The data and calculation methods used in the study are available from TurkStat and IPCC guidelines.

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REFERENCES

Bayraç, H.N. (2010). Enerji kullanımının küresel ısınmaya etkisi ve önleyici politikalar. Eskişehir Osmangazi Üniversitesi

Sosyal Bilimler Dergisi, 11 (2): 229-259.

Buratti, C., Fantozzi, F., Barbanera, M., Lascaro, E., Chiorri, M., & Cecchini, L. (2017). Carbon footprint of conventional and organic beef production systems: An Italian case study. Science of the Total Environment 576 (2017): 129-137. https://doi.org/10.1016/j.scitotenv.2016.10.075

Ceyhan, A., Akyol, E., Ünalan, A., Çınar, S., & Ali, W. (2020). Estimation of the carbon footprint in dairy sheep farm. Iranian Journal of Applied Animal Science, 10(4), 639-645.

Crosson, P., Shalloo, L., O'brien, D., Lanigan, G., Foley, P., Boland, T., & Kenny, D. (2011). A review of whole farm systems models of greenhouse gas emissions from beef and dairy cattle production systems. Animal Feed Science and Technology, 166: 29-45. https://doi.org/10.1016/j.anifeedsci.2011.04.001

Çetin, M., Saygın, S., & Demir, H. (2020). Tarım sektörünün çevre kirliliği üzerindeki etkisi: Türkiye ekonomisi için bir eşbütünleşme ve nedensellik analizi. Tekirdağ Ziraat Fakültesi Dergisi 17 (3): 329-345. https://doi.org/10.33462/jotaf.678764

Doğan, S., Özçelik, S., Dolu, Ö., & Erman, O. (2010). Küresel ısınma ve biyolojik çeşitlilik. İklim Değişikliği ve Çevre 3 (1): 63-88.

Ersoy, A.E. (2017). Türkiye'nin hayvansal gübre kaynaklı sera gazı emisyonları durumu ve biyogaz enerjisi potansiyeli. (Yüksek Lisans Tezi) Hacettepe Üniversitesi Fen Bilimleri Enstitiüsü, Ankara.

Emissions, F. A. O. (2000). Due to Agriculture. Global, Regional and Country Trends, 2018.

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A., & Tempio, G. (2013). Tackling Climate Change Through Livestock, A Global Assessment of Emissions and Mitigation Opportunities, (FAO), Rome.

Güven, G., & İlker, A. (2016). Food footprint in daily life: opinions about the consumption of convenience food. Journal of Theory & Practice in Education 12 (2): 403-426.

Herrero, M., Havlík, P., Valin, H., Notenbaert, A., Rufino, M. C., Thornton, P. K., Blümmel, M., Weiss, F., Grace, D., & Obersteiner, M. (2013). Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. Proceedings of the National Academy of Sciences, 110(52), 20888-20893. https://doi.org/10.1073/pnas.1308149110

IPCC, (2006). Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, NGGIP Publications, IGES, Japan.

Kara, G., Yalınız, İ., & Sayar, M. (2019). Konya ili hayvansal gübre kaynaklı sera gazı emisyonları durumu. Ulusal Çevre Bilimleri Araştırma Dergisi, 2(2), 57-60.

Kılıç, İ., & Amet, B. (2017). Bir süt sığırı işletmesinin karbon ayak izinin tahminlenmesi: Bursa örneği. Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi, 34 (Eksayı): 134-142. https://doi.org/10.13002/jafag4415

Kiggundu, N., Ddungu, S.P., Wanyama, J., Cherotich, S., Mpairwe, D., Zziwa, E., Mutebi, F., & Falcucci, A. (2019). Greenhouse gas emissions from Uganda's cattle corridor farming systems. Agricultural Systems, 176 (4): 102649. https://doi.org/10.1016/j.agsy.2019.102649

Kitani, O. (1999). Energy and Biomass Engineering. In: CIGR Handbook of Agricultural Engineering. ASAE, USA.

Koyuncu, M., & Akgün, H. (2017). Çiftlik hayvanları ve küresel iklim değişikliği arasındaki etkileşim. Uludağ Üniversitesi Ziraat Fakültesi Dergisi, 32 (1): 154-161.

Köknaroğlu, H., & Akünal, T. (2010). Küresel ısınmada hayvancılığın payı ve zooteknist olarak bizim rolümüz. Ziraat Fakültesi Dergisi, 5(1), 67-75.

MGM, Meteoroloji Genel Müdürlüğü (2023, September 1). https://www.mgm.gov.tr/eng/forecast-cities.aspx

Özpinar, S. (2023). Analysis of energy use efficiency and greenhouse gas emission in rainfed canola production (Case study: Çanakkale province, Turkey). Tekirdağ Ziraat Fakültesi Dergisi, 20 (1): 197-210. https://doi.org/10.33462/jotaf.1121863

Öztürk, H. (2007). Küresel ısınmada ruminantların rolü. Veteriner Hekimler Derneği Dergisi, 78 (1): 17-22.

Robertson, K., Symes, W., & Garnham, M. (2015). Carbon footprint of dairy goat milk production in New Zealand. Journal of Dairy Science, 98 (7): 4279-4293. https://doi.org/10.3168/jds.2014-9104

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., & de Haan, C. (2006). Livestock's long shadow: environmental issues and options. FAO, Rome, Italy.

TUIK, Türkiye İstatistik Kurumu (2023, September 9). https://biruni.tuik.gov.tr/medas/?kn=101&locale=tr

Türkeş, M. (2000). Hava, iklim, şiddetli hava olayları ve küresel ısınma. T.C. Başbakanlık Devlet Meteoroloji İşleri Genel Müdürlüğü: 187-205.

Yaylı, B., & Kılıç, İ. (2020). Süt sığırı işletmelerinin küresel ısınma potansiyelinin Tier-1 yöntemi ile tahminlenmesi. Uluslararası Biyosistem Mühendisliği Dergisi, 1 (2): 79-86.