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Research Article

Assessing the carbon footprint of Gaziantep University's sporium building: A step towards environmental awareness and climate action in Türkiye

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ABSTRACT

There are many human activities in our developing, growing, and easier world. The priority in reducing the effects of human activities on the environment is awareness. It is important to measure the direct and indirect effects of humans on the environment to raise awareness and create behavioral change. One of the measurement methods that have been widely used is carbon footprint. The gas defined as carbon is a greenhouse gas. Many studies have been carried out to reduce greenhouse gases and raise awareness on this issue. Within the scope of these situations, it is aimed to calculate the carbon footprint measurement of the Gaziantep University Sporium Building according to the annual natural gas and air conditioning data in Scope 1, electricity and water data in Scope 2, and garbage data in Scope 3.

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INTRODUCTION

Today, increasing population, urbanization, economic activities, and variable consumption habits increase the impact on the environment and natural resources. The current problems related to environmental pollution, climate change, desertification, and destruction of forests; water scarcity and global warming maintain their place on the world agenda (The Intergovernmental Panel on Climate Change (IPCC) [1]. With the increase in the amount of greenhouse gases (GHG) in the atmosphere as a result of human activities, temperature of the world rises. Along with the visible rays from the sun, ultraviolet and infrared rays also hit the earth's surface; some of them are reflected from the surface, while some of them are trapped by greenhouse gases, preventing their exit from the atmosphere. This obstacle, on the other hand, ensures that the earth's surface remains at a certain temperature. Due to this condition of GHG, atmospheric temperature is about 15°C [1].

It is possible to say that the most important component of the ecological footprint in our country is the carbon footprint (CF) with a rate of 46%. This study on CF, known as a type of ecological footprint, draws attention to the dimensions of the CF caused by the energy, production, and import structure in our country in particular [2]. To prevent climate change (CC) on a global scale, several international policies have been planned the United Nations Framework Conven-

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tion on Climate Change (UNFCCC) has been established and the Paris Agreement has put in force as of 2016. Within the scope of this agreement, the target of keeping the temperature increase at 1.5°C has been set, and it has been stated that this situation can greatly reduce the threat of CC. In this context, it is planned to provide technological, financial, and capacity-building support to developed countries to reduce the amount of GHG in these countries [3].

Since Türkiye is a party to the UNFCCC, it has also signed the Paris Agreement. For Türkiye certain responsibilities have been assigned like other countries, enabling it to make efforts to combat CC at a level that will not hinder sustainable development and economic developments worldwide. Following these studies, many protocols and agreements were signed, and participating countries made commitments by submitting national contribution declarations within their means to reduce and limit greenhouse gases. Türkiye prepared a National Contribution Declaration in 2015 and predicted that it would reduce greenhouse gas emissions by 30% by 2030. In this context, public institutions in Türkiye will need to analyze the current situation of their resources and activities within the scope of combating climate change.

In the light of these developments, as a case, the main purpose of this study is to calculate the CF of Gaziantep University Sporium Center, which many people visit and use daily, and to determine the carbon emission of this center.

LITERATURE REVIEW

GHG are gases present in the atmosphere that are part of a natural process called the greenhouse effect. Unlike other gases in the atmosphere GHG contribute to temperature regulation by affecting the total energy beneath the surface. However, in recent years, human activities have increased GHG, leading to global climate change [4]. Among the most common GHG are carbon dioxide (CO_2), methane (CH4), nitrogen oxides (NOx), chlorofluorocarbons (CFCs), and water vapor.

Increasing concentrations of GHG enhance their capacity to trap heat in the atmosphere, leading to global warming and CC. This situation can result in a range of adverse effects such as rising sea levels, extreme weather events, drought, and changes in ecosystems [5].

CF is a concept that measures the amount of GHG released into the atmosphere by an individual, organization, or product. It is typically expressed in terms of CO_2 equivalents, and is assessed at the personal, corporate, or product level. This monitoring process encompasses both direct and indirect GHG emissions, often involving various activities such as energy consumption, transportation, production, and consumption [6].

Personal CF is determined based on factors such as individuals' energy consumption habits, transportation preferences, and consumption patterns. At the corporate level, calculations consider companies' production processes, supply chains, and business operations. CF has gained significance as a concept supporting efforts to understand and reduce environmental impacts. In this context, it plays a fundamental role in the formulation and implementation of sustainability policies, serving as a cornerstone for informed and responsible environmental management. [7]. The issue of CF highlighted by the increase in carbon dioxide (CO_2) levels in the atmosphere due to industrialization and technological advancements is a prominent environmental concern worldwide. With the advent of the Industrial Revolution, the widespread use of fossil fuels and the growing energy demand have exacerbated the CF problem [8].

UNFCCC is an international agreement that was opened for signature in 1992, in Rio de Janeiro, to combat global climate change and mitigate its effects [3]. The main objectives of the convention are Combatting CC, Mitigating the Effects of Climate Change, Principle of Responsibility and Justice, and Alignment with Sustainable Development. The Kyoto Protocol has faced criticism, including challenges in certain countries meeting their commitments and the exclusion of developing countries from some obligations. In 2012, the Doha Amendment was adopted as a continuation of the Kyoto Protocol, but it also attracted criticism. The Paris Agreement establishes a framework for combating CC worldwide. It was adopted in 2015, during the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21). The agreement came into effect in 2016 [9].

The primary objective of the Paris Agreement was Limiting GHG Emissions. It sets the goal of keeping global warming below 2°C and supports efforts to reduce it to 1.5°C if possible. Secondly, Enhancing Adaptation and Resilience Efforts is the agreement that supports efforts to help communities adapt to and build resilience against the impacts of CC. Thirdly, Providing Financial Support is the agreement that envisions providing financial resources to support the efforts of developing countries in combating climate change. Finally, Transparency and Accountability is the agreement that requires countries to transparently report their emission reduction commitments and undergo regular reviews. Unlike the Kyoto Protocol, the agreement has a more flexible structure and adopts a more inclusive approach by calling on both developed and developing countries to share common responsibilities [9].

Türkiye's CF is based on the country's GHG emissions. These emissions can originate from energy production, industrial processes, transportation, agriculture, and other activities [10]. The country's CF can vary depending on factors such as economic growth, energy usage, and other considerations. Factors such as carbon intensity in energy production, fossil fuel usage in the transportation sector, industrial processes, and agricultural practices play a significant role in determining the CF [10].

Steps of improving energy efficiency, transitioning to renewable energy sources, implementing sustainable agricultural practices, and other environmental policies can contribute to reducing Türkiye's CF. Policies and sanctions on CF reduction in Türkiye are based on Climate Action Plans, Renewable Energy Incentives, Energy Efficiency Policies, Carbon-Free Transportation Policies, Carbon-Free Industry Policies, Forest Management and Afforestation Projects, and Climate Change Adaptation Programs. Policies supporting the use of electric vehicles, incentives for public transportation, and measures such as developing carbon-free transportation infrastructure are aimed at reducing carbon emissions in the transportation sector. Various policies and technological supports are provided to reduce carbon emissions in the industry. Protecting forests, afforestation projects, and sustainable forestry practices contribute to reducing carbon emissions.

MATERIALS AND METHODS

There are gaps in our country regarding the measurement of CF. In this study, inspired by green transformation initiatives such as the Green Campus Project; we aim to address the measurement of CF in real environments. The Gaziantep University Sporium Center presents a valuable opportunity for considering CF measurements.

DEFRA methodology

The Department for Environment, Food and Rural Affairs (DEFRA) [11] is a government agency in United Kingdom (UK) responsible for environmental protection, food production and standards, agriculture, and fisheries. Annually, DEFRA releases emission factors for the sources of environmental pollution from industries, manufacturing, residences, and transportation to address global warming. In a study conducted using emission factors published by DEFRA in 2023, calculations were performed to determine CF arising from the consumption of water, electricity, natural gas, and air conditioning in a sample building. To measure and examine the CF, the following scopes have been established by considering the existing emissions either directly or indirectly:

•Scope 1: Directly measured GHG emissions from the operation of the assessed building or through its vehicles. Therefore, it is considered a direct CF.

•Scope 2: Includes indirect GHG emissions from electricity, water usage, heating, and cooling.

•Scope 3: Encompasses other indirect GHG emissions not accounted for in Scope 2. Emissions arising from personnel commuting and business travel are evaluated within this scope.

Establishment boundaries are initially determined. The institution's name, full address, and affiliated organizations are identified. Their affiliations must be found and proven. It is mandatory to identify all other units affiliated with the institution. The boundaries of the organization's activities and functions are defined. A commitment statement is prepared by addressing the principles under the title of principles in the ISO 14064 regulation, with relevance to compliance, accuracy, integrity, consistency, accuracy, and transparency. Thus, the foundation of calculations and the initial steps to guide their implementation are prepared.

GHG emissions inventory of the organization must be compiled. If there are consolidations that can be made in the institution's units, they are identified. The emission values resulting from all other activities related to Scope 1 (all combustion and incineration, bioenergy, refrigeration and cooling gases, fuels used for internal transportation and transmission), Scope 2 (Electricity, Heat, and Steam), and Scope 3 are classified and listed based on transportation-related activities. By also looking at sections 4, 5, and 6 related to Scope 3, the factors related to carbon emissions are identified. Thus, the emissions for purchased materials are determined in Category 4 (such as paper, food, workwear, glass, metal equipment, etc.), emissions rates related to the use of the product in Category 5, and emissions from natural disasters such as invasion, earthquake, fire, etc., in Category 6. Emission sources and scopes of the Sporium Center at Gaziantep University are presented in Table 1. Scopes 1 and 2 are mandatory because they are direct sources of GHGs. The inspection year is selected based on the data situation. Then access should be provided to a document containing GHG emission rates that contain the most current protocol, as it can be updated periodically. If any software is used, one must verify that the latest published emission rates for calculations and ensure that these rates are accurately incorporated into the software settings to meet the requirement. If the software is open source, this can be done. If not, calculating corporate CF with the DEFRA method is safer and more accurate. With the DEFRA method, the emission values of factors (sources) used in combustion and incineration works used for production or service are determined, and the cumulative value is obtained. It must be determined whether banned gases are used where factors such as air conditioning, refrigerators, and all climate control devices are used. Data about the number, quantity, and characteristics of the used sources is also collected. Only reliable data sources, where official evidence can be found, should be used in determining the data. Invoices, calibration reports, technical specifications, tickets for journeys, scale measurements, legal permits, and SCADA data are accepted as official proofs.

In addition, information is collected on the purposes of water use, water sources, and carbon emission sinks in recycling activities. Information is collected on many issues such as usage permits, licenses, network water meter information, and calibrations. Wastewater and waste disposal agreements should be questioned. Corporate reports should be accessed. Emission values resulting from electricity, heat, or steam sources in Scope 2 are determined. Here, especially which country's electricity emission need to be determined. Factors for electric vehicles are examined in detail under a separate heading, and emission values are determined according to vehicle types. Emission values resulting from out-of-business transportation in Scope 3 are searched. Domestic and international travels, accommodations, and vehicles used are all used as factors with their official evidence. Issues such as the fuel types of vehicles used are clarified. By examining sections 4, 5, and 6 related to Scope 3, factors related to carbon emissions are determined. Thus, the values of GHGs from natural disasters such as invasions, earthquakes, and fire with all their official evidence are found.

After finding and calculating emissions in all scopes and categories, part of the report under reduction and improvement activities starts. Recommendations should be made under headings of energy demand and usage management, energy efficiency, technology or process improvements, GHG capture and storage, management of transportation and travel demands, fuel substitution or replacement, afforestation, waste reduction, alternative fuel, and raw material use to prevent waste disposal or burning, and refrigerant management. A report is further prepared for improvement activities, and in this report, the period covered by the target, including the target reference year and completion year, type of target, emission class, the amount and unit of reduction expressed according to the target type, climate science, reduction potential, international, national context, sectoral context considering criteria is determined. Sera gases management systems must be included in the organization's quality management systems in a manner consistent with the principles of this document. Consistency with the intended use of the GHG inventory is mandatory. Routine and consistent checks must be provided to ensure the accuracy and completeness of the GHG inventory. Errors and deficiencies should be identified and addressed; including documenting and archiving relevant GHG inventory records, including information management activities and key performance indicators. If the organization has a quality information management system, things become easier.

The responsibilities and authorities of those responsible for the development of the GHG inventory should be determined and reviewed. Appropriate training should be identified for members of the inventory development team. Establishment boundaries must be defined and reviewed. Review of GHG sources and sinks must be made. Selection of calculation approaches, including calculation and GHG calculation models used for data used in calculation approaches consistent with the intended use of the GHG inventory including data used for calculation and GHG calculation models, must be reviewed. Calculation approaches to ensure consistency between multiple facilities must be reviewed. A robust data collection system must be developed and maintained. Regular accuracy checks must be made. Periodic internal audits technical reviews and opportunities to improve information management processes must be periodically reviewed. GHG inventory must be documented and archived as required by quality management. Reasons for uncertainties should also be reported. Decisions taken under uncertainties are stated. Thus, the commitment statement is provided.

Table 1. Emission sources and scopes of Sporium Center at Gaziantep University

Scope	Emission Source	Units	Activity Data	Data Quality
Scope 1	Natural Gas	m^3	Monthly natural gas bills	Primary Data
	Air Conditioning	kWh	Monthly electricity bills	Primary Data
Scope 2	Electricity	kWh	Monthly electricity bills	Primary Data
	Water	m^3	Monthly water bills	Primary Data
Scope 3	Waste	Kg	Monthly amount of garbage thrown away	Primary Data

Computational analysis

Some methods such as IPCC [1], Environmental Protection Agency (EPA) [12], DEFRA [11], and ISO 14064 are used to calculate the amount of greenhouse gases. According to DEFRA (2023) [11], three different coverage approaches can be used in carbon footprint calculations in an excel sheet. In this study, within the scope of Gaziantep University Sporium Center, CF resulting from natural gas consumption and air conditioning use with the Scope 1 method, from electricity and water use with the Scope 2 method, and the amount of garbage with the Scope 3 method was calculated. In general, there are several formulas for calculating CF. These is;

•CF = Monthly Consumption x Emission Factor (1)

•Energy Consumption [TJ] = Fuel Consumption [t] × 10-3 × Conversion Factor [TJ/kt] (2)

•Carbon Content [Gg C] = Carbon Emission Factor [TC/TJ] × Energy Consumption [TJ] × 10-3 (3)

•Carbon Emission [Gg C] = Content of Carbon [Gg C] × Carbon Oxidation Ratio (4)

•Carbon Dioxide Emission [Gg CO_2] = Carbon emission [Gg C] × 44/12 (5)

Eq.1 is used directly when we multiply consumption data by carbon emissions. Eq.2-5 uses the formulas in the equations to transform consumption data.

CF due to natural gas consumption

Since natural gas is used only in the heating system in the sports center, natural gas consumption only occurs during the winter season and on certain dates of the year by Gaziantep Governorship. It is stated that the winter season is between 15 November and 15 April. For this reason, central heating systems are used only within the date ranges determined by the governorship. It provides service every day of the week, including weekdays and weekends. To determine the CF of the sports center resulting from natural gas consumption, it is of great importance to make accurate calculations according to daily working hours of the sports center and the heating season, to observe the results well and interpret them correctly. Natural gas is consumed for an average of five months during the winter season. Since the natural gas in the sports center was allocated from the Gaziantep University heating center, monthly calculations could be made by converting the paid bills into m3. Calculation was made by the authorized personnel of the sports center using the records of natural gas bills and is presented in Table 2.

Table 2. Monthly natural gas consumption amounts the year 2023

Months	Natural Gas (m3)	CF (kg CO_2e)	Months	Natural Gas (m3)	CF (kg CO_2e)
January	29500	60180	July	14000	28560
February	30000	61200	August	14000	28560
March	22500	45900	September	19000	38760
April	15000	30600	October	22000	44880
May	14500	29580	November	28000	57120
June	14000	28560	December	29500	60180
				Total (Kg) (yearly)	514080

Table 3 shows the carbon emissions factor for natural gas consumption published by DEFRA in 2023. The equivalent emission factor in Table 3 is taken as the DEFRA natural gas emission factor. This emission factor used in CF calculations is multiplied by natural gas consumption values to calculate the equivalent carbon footprint using Equation 1;

Table 3. DEFRA 2023 natural gas emission factor

About Natural Gas Consumption Emission Factor	Equivalent Emission Factor kgCO_2e 2.04
CF = Monthly Gas Consumption x Emission Factor	

Calculated CF are shown as monthly and one-year totals. The emission factor used in the calculations was taken as 2.04 kgCO_2e. According to calculations, CO_2 emission was determined as 514080 kg by multiplying the total amount of m3 natural gas consumed in a year with the carbon emission coefficient using Eq 1.

Since more natural gas is used in the winter months, more CO_2 is emitted compared to the summer months. It is calculated by considering that natural gas is used only in poolside showers and heating pool water during the summer months. Apart from these, another reason why natural gas carbon emission is low in the summer months is that the number of visitors to the sports center in the summer months is less than in the winter months.

CF from electricity consumption

The most used type of energy in sports center is electricity. This is because there are many activities in the sports center like pools, fitness, game rooms, astroturf pitches, basketball courts, etc. For these reasons, electricity is used in the sports center for twelve months of the year. Some machines operate twenty-four hours a day, and every day of the week. It has also been determined that electricity use varies according to months and seasons. Since there is no air conditioning in the winter months, it was determined that electricity usage was less than in the summer months. The number of visitors to the facility also made a difference in electricity usage. During calculation, monthly amount of electricity consumed was calculated based on the invoices determined by the Gaziantep University Administrative and Financial Affairs Department. It was converted into kilowatts according to the amount used by looking at the determined bills. The twelve-month electricity usage amount according to the electricity bills received is presented in Table 4.

Table 4. Monthly electricity consumption carbon emissions

Months	Monthly electricity consumption(kWh)	CF ($kgCO_2e$)	Months	Monthly electricity consumption amounts(kWh)	CF ($kgCO_2e$)
January	398452	82479.56	July	416556	86227.09
February	401865	83186.06	August	416865	86291.06
March	409563	84779.54	September	411976	85279.03
April	413048	85500.94	October	409368	84739.18
May	414535	85808.75	November	402192	83253.74
June	414898	85883.89	December	403767	83579.77
				TOTAL (kg) (yearly)	1017008,6

Table 5 shows the carbon emission factor for electricity consumption published by DEFRA in 2023. The equivalent emission factor in Table 5 is considered as the DEFRA electricity emission factor. This emission factor, used in carbon footprint calculations, is multiplied by electricity consumption values to calculate the equivalent carbon footprint. Using Equation 1;

In Table 4, the calculated CF are shown as monthly and 1-year total. The emission factor used in the calculations was taken as 0.207 $kgCO_2e$. In calculations, by multiplying the total kW value used for a year with the carbon emission coefficient, CO_2 emission was found to be 1017008.6 kg using Equation 1. Since more electricity is used in the summer months, slightly more CO_2 is emitted compared to the winter months. It was determined that the reason for this was the use of air conditioners (AC) in the sports center during the summer months. In addition, to determine the amount of carbon dioxide emissions resulting from electricity use in all sections of the sports center, CO_2 emissions of each section were calculated separately.

CF due to water consumption

There are many areas in the sports facility where water is used. The first of these areas is the pool. It is actively used twelve months of the year. Since pool maintenance is done once a week, all the water in the pool is renewed. General use of water is swimming pool, shower, WC, Canteen, Building cleaning, and irrigation in the garden. It is used in areas such as irrigation of basketball and football fields. An average of 200 people takes a shower per day at the facility. When calculating monthly water usage in the shower section, it is calculated based on the amount of water each person uses while taking a shower for an average of 5 minutes. Since there is active water use all throughout the year, not much difference was observed in monthly CO_2 emissions. Since there is no clear information on water use in each part of the facility, the amount of entire water used was calculated. In these calculations, the monthly water use was calculated based on the invoices determined by the Gaziantep University Administrative and Financial Affairs Department. It was converted to m3 according to the amount used by inspecting the determined invoices. The annual water use according to incoming water bills is presented in Table 6.

Table 5. DEFRA 2023 electricity emission factor

Pertaining Electricity Consumption Emission Factor	**Equivalent Emission Factor** **$kgCO_2e$** **0.207**
Carbon Footprint = Monthly Electricity Consumption x Emission Factor	

Table 6. Monthly water consumption amounts and carbon emissions

Months	Water (m^3)	CF ($kgCO_2e$)	Months	Water (m^3)		CF ($kgCO_2e$)
January	110000	19470	July	137000		24249
February	115000	20355	August	135000		23895
March	117500	20797.5	September	125000		22125
April	123000	21771	October	120000		21240
May	128000	22656	November	110000		19470
June	135000	23895	December	115000		20355
				Total (Kg)	(yearly)	260278.5

Table 7 shows the carbon emission factor for water consumption published by DEFRA in 2023. The equivalent emission factor in Table 9 is taken as the DEFRA water emission factor. This emission factor, used in CF calculations, is multiplied by water consumption values to calculate the equivalent CF using Equation 1.

Table 7. DEFRA 2023 water emission factor

Water Consumption Emission Factor	Equivalent Emission Factor $kgCO_2e$ 0.177
CF = Water Consumption Data x Emission Factor	

In Table 6, the calculated CF amounts are shown as monthly and annually. The emission factor used in the calculations was taken as 0.177 $kgCO_2e$. According to calculations, when the annual total m3 value used is multiplied by the carbon emission coefficient, CO_2 emission is found to be 260278.5 kg using Equation 1. When an observational evaluation was made, it was seen that the most water usage areas were pools and showers. As a result of the calculations, it was seen that the amount of carbon emissions in the summer months was higher than in the winter months, depending on the amount of water used. Table 10 shows that carbon emissions in June, July, and August are slightly higher than the other months. The main reason for this fact is that the pool is used more in summer and therefore the showers are used more.

CF due to air conditioning use

During the winter months, natural gas is used for heating in the sports center. In summer, air conditioning is used for cooling purposes. Although using an AC may seem like consumption of electricity, air conditioners (ACs) contain gas. This gas affects carbon emissions. During the summer months, the sports center is open every weekday. During summer months, ACs operate between these hours. There is a total of 6 ACs in the facility. To determine the CF of the sports center resulting from the use of AC, it is of great importance to make accurate calculations according to the daily working hours of the sports center and the cooling season and to observe and interpret the results. The carbon emissions released from the effect of AC in the sports center on electricity consumption were calculated while calculating electricity consumption. In this section, only the carbon emissions resulting from the exhaustion time of the air conditioning gas are calculated. This calculation was done considering that the air conditioners used in the sports center are industrial ACs and contain R410A gas as presented in Table 9.

Table 8. Monthly air conditioning usage amounts and carbon emissions

Months	AC (kg)	CF ($kgCO_2e$)	Months	AC (kg)	CF ($kgCO_2e$)
January	11.3	21741.2	July	17.3	33285.2
February	11.4	21933.6	August	17.7	34054.8
March	10.6	20394.4	September	15.5	29822
April	14.6	28090.4	October	14.7	28282.8
May	15.3	29437.2	November	10.9	20971.6
June	17.4	33477.6	December	11.1	21356.4
				Total (Kg) (yearly)	322847.2

Table 9 shows the carbon emission factor for industrial air-conditioning gas use published by DEFRA in 2023. The equivalent emission factor in Table 12 is taken as the DEFRA industrial air conditioning gas use emission factor. This emission factor used in CF calculations is multiplied by industrial AC usages to calculate the equivalent CF using Equation 1.

Table 9. R410A gas emission factor

	Equivalent Emission Factor
Emission Factor Related to Industrial AC Gas Use	**$kgCO_2e$**
	1924

CF = R410A gas usage data x Emission Factor

In Table 8, the calculated CF amounts are shown as monthly and annually. The emission factor used in the calculations was taken as 1924 $kgCO_2e$. According to calculations, when the annual total kg value of R410A air conditioning gas used is multiplied by the carbon emission coefficient, CO_2 emission is found to be 322847.2 kg using Equation 1.

There is a calculation on R410A gas used by the 6 air conditioners. An average AC consumes 13.6 kg of R410 gas after approximately 2 years (365x2x4=2920 hours) by operating 4 hours a day. According to this ratio, an AC that works 13 hours a day works 390 hours a month. Since there are six ACs in the facility, they operate for 2340 hours. Six ACs consume a total of 10.9 kg of R410 gas. The consumption amount in all months was calculated accordingly and multiplied by the carbon emission rate of R410A gas. As a result of these calculations, it was seen that less AC was used in the winter months than in the summer months (see Table 8).

CF from discarded garbage

There are many areas within the sports facility. In addition to the pool, fitness, and playgrounds, there is also a canteen where food and beverages are sold. It is provides service during the time the facility is open between 09.00 and 22.00 on weekdays and weekends. To determine the CF resulting from the amount of garbage in the sports center, it is of great importance to make accurate calculations, observe and interpret it according to the daily working hours of the sports center and the number of visitors in the canteen. The average amount of garbage using the canteen section on a monthly and annual basis is given by the personnel working at Gaziantep University Sporium Center. Monthly and annual amounts of garbage collected are presented in Table 10. Table 11 shows the carbon emission factor for the amount of litter published by DEFRA in 2023.

The calculated CF is shown monthly and annually. The emission factor used in the calculations was taken as 21.281 $kgCO_2e$. When the total annual kg used was multiplied by the carbon emission coefficient, CO_2 emission was found to be 925723.5kg. Since the total amount of garbage in the facility was calculated in general, it could not be determined in which areas more garbage was discarded.

It was seen that the amount of carbon emissions in the winter months was higher than in the summer months, depending on the amount of garbage. The main reason for this is that the number of people visiting the facility in the summer months varies between 1000-1500 people whereas this value in the winter months is between 3000-3500 people. It was observed that seasonal and monthly carbon emissions differ depending on the number of visitors.

CF of the facility due to the number of visitors

There are many activity areas in the sports facility. Use of these activity areas varies depending on the number of visitors. These are the amount of garbage generated, and the amount of water used based on the number of visitors to the facility, use of game tables in playgrounds depending on the visitor density of the facility. Data provided by the personnel working at Gaziantep University Sporium Center, the number of visitors to the sports center could be calculated monthly. In Table 12, the monthly CF per person was calculated by adding up the CO_2 emissions of natural gas, air conditioning, electricity, water, and garbage used separately for each month and dividing by the number of visitors of that month. It was determined that the number of people visiting the facility was inversely proportional to the amount of CF per person. One of the most important reasons for this was the use of electricity and natural gas in the facility's operating areas, regardless of the number of visitors. CF data according to the number of visitors is given in Table 12. Using Equation 1;

January Carbon Footprint=268994 $kgCO_2e$/3200 visitors= 84 carbon footprint

April Carbon Footprint =239381 $kgCO_2e$ / 2150 visitors= 111 carbon footprint

Table 10. Monthly amounts of garbage and carbon emissions

Months	Garbage (kg)	CF ($kgCO_2e$)	Months	Garbage (kg)	CF ($kgCO_2e$)
January	4000	85124	July	3250	69163.25
February	4100	87252.1	August	3150	67035.15
March	3750	79803.75	September	3450	73419.45
April	3450	73419.45	October	3700	78739.7
May	3400	72355.4	November	3800	80867.8
June	3350	71291.35	December	4100	87252.1
				Total (Kg)(yearly)	925723.5

Table 11. DEFRA 2023 garbage emission factor

	Equivalent Emission Factor
Emission Factor for the Amount of Garbage	**$kgCO_2e$**
	21.281
CF = Garbage amount data x Emission Factor	

Annual CF calculations

Gaziantep University Sporium Center has been in service since 2014. Many activities are carried out in the sports center, whose number of visitors has been increasing day by day since the day it was opened. While performing these activities, some consumption and waste occur. There are consumption and wastes such as natural gas consumption, air conditioning consumption, electricity consumption, water consumption, and amount of garbage. It is open every day of the week, on weekdays and weekends, between 9 am and 10 pm. The carbon emissions of the sports center resulting from this consumption and waste were calculated separately according to the amount, type, and time of use. These calculations were calculated in line with the data by the staff of Gaziantep University Thermal Center and Sporium Center. Monthly carbon footprint calculations based on the monthly usage amounts of what is consumed in the facility and the numbers of visitors are given in Table 12. According to these data, annual average CO_2 emissions and monthly average CF per person were calculated. Finally, carbon emissions are presented in Table 13, showing the Monthly Average CO_2e and Average Monthly CF per person.

Table 12. Carbon footprint according to the number of monthly visitors

Months	Number of Visitors	CF ($kgCO_2e$)	Months	Number of Visitors	CF ($kgCO_2e$)
January (84.1)	3200	268994.8	July (161)	1500	241484.5
February (103.4)	2650	273926.8	August (184.5)	1300	239836
March (111.9)	2250	251675.2	September (110.8)	2250	249405.5
April (111.3)	2150	239381.8	October (105.3)	2450	257881.7
May (123	1950	239837.3	November (87.2)	3000	261683.1
June (124.7)	1950	243107.8	December (85.2)	3200	272723.3
				Total (Kg) (yearly)	3039937.8

Table 13. Annual CF of Gaziantep University Sporium Center

Monthly Average CO_2e	**253328.15 kg**
Average Monthly CF Amount per Person	**116 kg**

DISCUSSION

CF of the Gaziantep University Sporium Center was assessed by calculating the consumption of natural gas, water, air conditioning, electricity, and garbage. Equivalent emission coefficients published by DEFRA in 2023 were utilized in the calculations. Analysis of the calculated values reveals higher electricity carbon emissions in summer compared to winter. This is primarily attributed to increased air conditioning usage and more active utilization of the facilities during the summer months. It is observed that natural gas carbon emissions are higher in winter than in summer, primarily due to the facility's use of natural gas for heating during the colder months. There is minimal variation in water carbon emissions between winter and summer months, largely because the pool operates year-round, consuming water consistently. Higher AC R410A gas carbon emissions are observed in summer, reflecting the facility's use of natural gas for cooling during warmer months. Lower carbon emissions from garbage disposal are observed in summer compared to winter, primarily due to reduced visitor numbers during the summer months. It is noted that the average carbon footprint per person is inversely proportional to the number of facility visitors, as factors such as water usage in the pool and energy consumption remain relatively constant regardless of visitor numbers.

It is clear that sports competitions or the lives of athletes significantly impact carbon footprint. The average carbon emissions per person for a sports competition have been determined to be 100 kg in a sport activity [13]. Comparing our finding of 109 kg, we conclude that Gaziantep University Sporium Center is close to the average value.

CONCLUSION

CF calculation was made at the Gaziantep University Sporium Center for the year 2023. It has been calculated as kg equivalent CO_2;

•514080 $kgCO_2e$ emissions were calculated from the use of natural gas using the DEFRA Methodology Scope 1 approach of the facility's primary CF.

•322847.2 $kgCO_2e$ emissions were calculated from air conditioning by using the DEFRA Methodology Scope 1 approach of the facility's primary carbon footprint.

•1017008.6 $kgCO_2e$ emissions were calculated from electricity consumption using the DEFRA Methodology Scope 2 approach of the facility's primary carbon footprint.

•260278.5 $kgCO_2e$ emissions were calculated for plant's water use.

•925723.5 $kgCO_2e$ emissions were calculated for garbage disposal using the DEFRA Methodology Scope 3 approach.

The average monthly CO_2 emission of the facility has been calculated as 253328 tCO_2e. The average amount of CF per person per month was calculated as 116 kg.

According to the data, the largest share of CF belongs to electricity, natural gas, and air conditioning consumption, respectively. Since the largest share is electricity consumption, reducing emissions resulting from electricity consumption is an important step in reducing the CF. Our university needs to turn to renewable energy sources, and work on the effective use of energy in buildings should be accelerated. Electricity consumption mainly comes from lighting, heating/cooling, and air handling units, dressing rooms, game rooms, fitness centers, fields, and elevator use. Economical lamps are generally used in our university. Expanding the use of photocell lamps, replacing the equipment used in dressing rooms, game rooms, and fitness centers with energy-saving vehicles, and choosing stairs instead of elevators will reduce the carbon emissions caused by electricity for both the environment and our health.

DATA AVAILABILITY STATEMENT

The author confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

USE OF AI FOR WRITING ASSISTANCE

Not declared.

ETHICS

There are no ethical issues with the publication of this manuscript.

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