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Research on the Carbon Footprint Caused by Micro-Level Sports Facilities: Carbon Footprint of Ardahan University Sports Facilities in Turkey

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ABSTRACT

The aim of this research is to calculate the carbon footprint of 2 sports complexes located at the Ardahan University Campus in Turkey. The Intergovernmental Panel on Climate Change (IPCC) calculation methodology (Tier 1 method) was used for the analysis of the data obtained. As research data, the electricity and natural gas consumption amounts used in 2021 in 2 sports complexes located in Ardahan University Campus were used. The research was limited to Ardahan University due to insufficient data and pandemic conditions. As a result of the analysis of the data obtained, the carbon footprint of 2 sports complexes for 2021 was calculated as 7,621,285.5 tons. According to the calculations, 98.4% of the carbon footprint of the sports complexes on the university campus is due to natural gas consumption. This situation can be attributed to the need for natural gas from an intense heating source due to the long and harsh winter seasons due to the geographical location of the province of Ardahan. As a result, it can be said that in order to reduce the carbon footprint of sports facilities, it is necessary to turn to renewable energy sources, to use materials suitable for recycling in the construction of the facilities and to control waste generation.

Keywords: environmental sustainability, carbon footprint, sports, sports facilities, sustainable development.

INTRODUCTION

Although it is known that human behaviours have many effects on the environment and that there is a strong relationship between these behaviours and the environment, it is understood that the main cause of environmental problems is the attitudes and behaviours exhibited by people (Balteanu & Dogaru, 2011, p.1; Keleş, 2015, p. 34). Increasing environmental problems and environmental sustainability concerns are one of the most important problems faced by societies in the world (Shahroh et al., 2020). When the literature is examined, these negative effects of people on the environment are expressed as "Carbon Footprint". Carbon footprint is the amount of greenhouse gas in terms of carbon dioxide equivalent, which is caused by the behaviour and activities of people (transportation, electricity, water, fuel, etc.) (Toröz, 2015, p. 68). In a more comprehensive expression, carbon footprint is accepted as a general expression used for environmental pollution, greenhouse gas and carbon dioxide emissions caused by individuals, institutions, businesses and organisations (Global Footprint Network, 2017). The carbon footprint in the world we live in is growing day by day due to the negative relationship between humans and the environment. For example, carbon dioxide emissions in Turkey are twice the existing biodiversity. At the same time, natural resources in Turkey are consumed twice as fast when compared to the life cycle (Global Footprint Network, 2017).

The acceleration of social life, the increase and diversification of people's vital activities, and the unconscious continuation of consumption cause the carbon footprint to grow day by day. This situation also raises concerns about environmental sustainability. In recent years, these environmental concerns have been associated with the sports industry. Because it can be said that one of the areas where human behaviours is concentrated is the sports sector. Perira et al., (2019) states that the negative environmental effects caused by sports have become evident, the carbon footprint has grown, and measures should be taken within the sports sector. The International Olympic Committee attributes this negative situation to the establishment of sports, the increasing organisation and the number of participants (International Olympic Committee, 2009).

While establishment and increasing organisations in the sports sector cause the carbon footprint to grow, the attitudes and behaviours of active and passive participants also accelerate this process. When the research studies are examined, it is possible to list the negative environmental effects caused by the sports sector in general as follows:

- Soil, air and water pollution,
- High energy use for lighting
- Greenhouse gas emissions from electricity and fuel,
- Noise and sound pollution
- Consumption of natural resources,
- Soil erosion,
- Air pollution from tracker vehicles
- Environmental pollution caused by fossil fuels
- Environmental pollution caused by waste on match days (International Orienteering Federation, 2007; Mallen & Chard, 2011; Balcı & Koçak, 2014).

Research on the carbon footprint caused by the sports sector and especially the reports prepared by the International Olympic Committee have mobilised countries in this regard and accelerated the studies. For example, the Italian Association of Sports for All prepared a comprehensive "Sustainability in Sports" report in 2012 and made a systematic assessment of the sources of carbon footprint in the sports sector. This eval

uation is presented visually as follows:

Table 1. Systematic analysis of carbon footprint in sport (compiled by the author according to Sorrentini, 2021)

SPORT
Material • Production • Transport • Construction • Maintenance
People • Accommodation • Supplying • Transport • Hygiene measures • Merchandising
Pollution • Water • Soil • Air
Garbage • Waste • Noise • Disturbance Factories

In the report prepared by the Italian Association of Sports for All, the source of the carbon footprint in sports is grouped under two headings. These are establishment in sports and participation in organisations. While water, soil and air pollution come to the fore due to the installation, it is understood that resource and energy consumption are also determinant in this process. On the other hand, the negative environmental effects caused by people in the process of participation in organisations due to transportation, accommodation, purchasing and consumption draw attention (Sorrentini, 2021).

As the subject of this research, it can be said that the most important factor in the formation and growth of carbon footprint in sports is sports facilities. Barghchi et al., (2010) state that the carbon footprint that arises due to the construction of new sports facilities, the maintenance and repairs of existing ones, and the need for high energy and natural resources is an important risk factor for environmental sustainability goals. For example, the use of large amounts of water, energy and chemi-

cals to keep a field ready for competitions causes high greenhouse gas and carbon dioxide emissions (United Nations Climate Change, 2022). The carbon footprint caused by sports facilities in different branches threatens sustainable environment and sports targets.

Waste waters used in the production of artificial snow for a ski slope cause great damage to the surrounding ecosystem where the ski slope is located (Schmidt, 2006). Or, the destruction of vegetation in the region during the construction of a golf course can disrupt the ecological balance (Thibault, 2009). At the same time, the amount of water used for irrigation of a golf course is approximately 1 million cubic meters. This amount is considered to be equivalent to the water consumption of a residential area with a population of almost 12 thousand (Schouten, 2003, p. 17). Or, in a public swimming pool, 400 tons of carbon dioxide are released annually due to lighting, heating and chemicals used (Caneva, 2010).

It is obvious that the negative environmental effects of the sports sector are increasing and it is an area where precautions should be taken; mass interest and participation in sports is increasing day by day. This situation brings the relationship between ecological balance and sports to a more sensitive point. One of the most important parts of environmental sustainability targets on a global scale is the sports sector. It can be said that the existing literature agrees that sports organisations and sports facilities increase their carbon footprint. It can be stated that there is no environmentally friendly approach in mass behaviour related to production, consumption, transportation and accommodation, especially in large sports organisations. On the other hand, carbon dioxide and greenhouse gas emissions, especially from fossil fuels, increase the carbon footprint every day (de Vasconcelos & de Macedo Filho, 2020). Such situations require organisations and those responsible for sports activities to take appropriate strategies and measures to support the diffusion of low-impact technologies and high energy savings, as well as to encourage athletes and spectators to act responsibly when it comes to the environment (Soorentini, 2021).

The aim of this research, which is based on the increasing relationship between sports and the environment and the importance of this relationship, is to calculate the carbon footprint of 2 sports complexes located in Ardahan University Campus. For this purpose, an answer was sought for the following research question:

• What is the carbon footprint of the 2 sports complexes located in Ardahan University Campus?

METHOD

Research Methodology

This study was carried out within the scope of quantitative research methods. In order to answer the stated research question, the carbon dioxide emission amount (carbon footprint) of 2 sports complexes located on the campus was calculated by means of The Intergovernmental Panel on Climate Change (IPCC) calculation methodology (Tier 1 method). The IPCC method has gathered emission calculation methods under three headings. These are evaluated in 3 different categories called Tiers (Binboğa & Ünal, 2018). While the Tier 1 method is a method that requires less and simple data in general, Tier 2 and 3 methods are complex calculation methods that require more data (Atabey, 2013, p. 45). In order to calculate the carbon footprint of 2 sports complexes with the Tier 1 calculation method, the carbon footprint resulting from the electricity and natural gas consumption used for lighting and heating in the sports complexes was calculated.

Inventory calculations consist of 6 main headings in the IPCC Guideline, which includes how the resulting greenhouse gas data will be calculated, evaluated and reported. These titles are as follows:

- Energy use
- Processes and processes to industry
- Use of solvents and other products
- Agriculture
- Earth geography and forest use
- Wastes generated

Data Collection and Analysis Process

In order to calculate the carbon footprint of the sports complexes, the amount of electricity and natural gas consumed in the sports com-

plexes throughout 2021 was obtained from the Administrative and Financial Affairs Department of Ardahan University. The amount of electricity and natural gas consumed in a 12-month period in 2021 constitutes the data set of the research. Due to the inability to reach large-scale and sufficient data and the Covid-19 pandemic processes, the research was limited to Ardahan University sports facilities. The total amount of natural gas and electricity consumed in 2 sports complexes in Ardahan University Campus during the 12-month period throughout 2021 is presented in the table below:

Table 2. Natural gas and electric consumption amount in 2021

Energy Type	Amount of Consumption (Cubic Meters)	Amount of Consumption (Tons)	Amount of Consumption (Gigagram)
Natural Gas	3.555.959,6068	2.844.412,08	2.844,412
Electric	258,393 KWh		

* Converted to tons and gigagrams by multiplying their densities according to energy type.
According to the density of natural gas;
1 m3 =0.7999 t
1 t = 10^{-3} Gg= 0.001 Gg

The analysis process of the data set obtained for the research consists of two steps. These are the calculation of the carbon footprint due to electricity consumption and the calculation of the carbon footprint due to natural gas consumption. In the calculation of the carbon footprint caused by the electrical energy consumed for the purpose of lighting and heating in sports facilities, the IPCC carbon dioxide emission factor of 0.584 tons/mWh was used (Toröz, 2015, p. 79). The formula below was used to calculate the carbon footprint due to electricity consumption (Binboğa & Ünal, 2018).

CO2 Emission = Amount of Electricity Used x 0.584 tons/mWh

The carbon footprint calculation process related to the use of natural gas in sports complexes consists of four steps. In the first step, energy consumption is calculated depending on the amount of natural gas use, carbon content is calculated in the second step, carbon emissions are calculated in the third step, and carbon dioxide emissions are calculated in the fourth step, and the carbon footprint of the sports complexes is measured (Binboğa and Ünal, 2018). Detailed information and calculation methods regarding the calculation in these four steps are presented below.

Step One

First, it is necessary to calculate the amount of natural gas-based energy consumption used in sports facilities. In the calculation of this energy amount, the total fuel consumption is multiplied by the net calorific value. For this, the formula below was used (Binboğa and Ünal, 2018).

Energy Consumption (TJ) = Fuel Consumption (t)× Net Calorific Value (TJ/Gg)

The net calorific values of fuel types are the values included in the "Communiqué on Monitoring and Reporting of Greenhouse Gas Emissions" published in the Official Gazette dated 22.07.2014 and numbered 29068 and specified in the IPCC 2006 Guidelines (Binboğa & Ünal, 2018). These values are presented in the table below:

Table 3. The net calorific values of fuel types

Fuel Type	Net Calorific Values (TJ/Gg)
Benzine	44,3
Diesel	43,0
LPG	47,3
Lignite Coal	11,9
Natural Gas	48,0

Second step

In the second step, it is necessary to calculate the carbon content for the natural gas used in sports complexes. For this, the calculation is made by multiplying the carbon emission factor expressed in the IPCC guide with the energy consumption value calculated in the first step. The formula below was used for this calculation (Binboğa & Ünal, 2018). In addition, the emis-

sion factors of the fuels expressed in the IPCC guide are presented in the table below:

Carbon Content (t C) = Carbon Emission Factor (t C/TJ) × Energy Consumption (TJ)

Table 4. Emission factor of fuels

Fuel Type	Emission Factors (t C/TJ)
Benzine	18,90
Diesel	20,20
LPG	17,20
Lignite Coal	27,60
Natural Gas	15,30

Source: Turkish Statistical Institute (2013). National Greenhouse Gas Inventory Report, 1990-2012.

Third step

In the third step, it is necessary to calculate the carbon emission for the natural gas used in sports complexes. For this calculation process, the carbon content value found in the second step is multiplied by the oxidation rate of the fuels. Considering the oxidation percentage (combustion efficiency) values of the fuels by the IPCC, the value for gaseous fuels (Natural Gas) is 0.995. The formula below was used for this calculation (Binboğa & Ünal, 2018). In addition, the oxidation rates of the fuels expressed in the IPCC guideline are presented in the table below:

Carbon Emission (Gg C) = Carbon Content (Gg C) × Carbon Oxidation Rate

Table 5. Oxidation ratios of fuels

Fuel Type	Oxidation Ratio
Benzine	0,99
Diesel	0,99
LPG	0,99
Lignite Coal	0,98
Natural Gas	0,995

Fourth step

In the fourth and final step, the carbon dioxide emission for the natural gas used in sports complexes should be calculated. For this calculation process, the ratio of the molecular weight of carbon dioxide to the molecular weight of carbon is used. This ratio is 44/12. At this stage, the carbon emission value calculated in the third step is multiplied by the 44/12 value (Binboğa and Ünal, 2018). And at the end of these four steps, the natural gas-sourced carbon footprint of the sports complexes will be calculated. For this calculation, the formula below was used (Binboğa and Ünal, 2018).

CO2 Emission (Gg CO2) = Carbon Emission (Gg C) × (44/12)

Considering the research conducted by Binboğa and Ünal (2018), the formula and steps of carbon footprint calculation were followed in this study and these steps were explained in detail above. The calculation methods and formulas used in the research process were reduced to a single formula by the researcher. The formula compiled by the researcher for use in carbon footprint studies in the sports sector is given below.

CO2 Emission = Total Fuel Consumption (t) x Net Calorific Value x Carbon Emission Factor x Carbon Oxidation Rate x 44/12 x 10^{-6}

RESULTS

In this part of the research, the findings related to the carbon footprint calculated based on the natural gas and electricity consumption of the 2 sports complexes in the Campus of Ardahan University in 2021 are included.

The carbon dioxide emission (carbon footprint) due to natural gas and electricity consumption of 2 sports complexes located in Ardahan University Campus in 2021 has been calculated as 7,621,285.5 tons. According to the calculations, 98.4% of the carbon footprint of the sports complexes on the university campus is due to natural gas consumption. This situation can be attributed to the intense heating source natural gas need due to the long and harsh winter seasons in terms of the geographical location of the province of Ardahan.

Table 6. Carbon footprint of 2 sports complexes

Energy Type	Natural Gas	Electric	Total
Amount of Consumption (Cubic Meters)	3,555,959,6	258,393 KWh	
Amount of Consumption (Tons)	2,844,412,0894		
Amount of Consumption (Gg/C)	2,844,412		
Net Calorific Value (TJ/Gg)	48,0		
Energy Consumption (TJ)	136,531,7802		
Carbon Emission Factor (tC/TJ)	15,3		
Carbon Content (Tons)	2,088936,2385		
Carbon Content (Gg/C)	2,088,9362		
Carbon Oxidation Ratio	0,995		
Carbon Emission (Gg/C)	2,078,4915		
Carbon Emission Value	44/12		
CO_2 Emission (Gg/C)	7,621,1357		
CO_2 Emission (t)	7,621,135,4	150,90	7,621,285,5 CO_2

DISCUSSION

In this study, in which the carbon footprint of the 2 sports complexes in Ardahan University Campus is calculated, the findings related to a part of the negative relationship between sports and the environment were tried to be presented. The discussion part of the research was designed with a general literature review, since there was no domestic research that only measures the carbon footprint of sports facilities.

The acceleration of the understanding of establishments in sports, and the maintenance and repair of existing facilities, cause a cost in terms of the environment we live in. This cost can be considered as the rapid consumption of natural resources, greenhouse gas and carbon dioxide emissions due to high energy use. It can be said that this situation, which threatens a sustainable environment and sports understanding, will grow exponentially if no precautions are taken.

Buildings account for more than 40% of the world's energy use, resulting in more carbon dioxide emissions than the transport and industry sectors alone. In addition, this increased energy consumption of sports facilities has become an important environmental problem, as they use extraordinary amounts of energy. For example, the annual energy consumption of the Dallas Cowboy stadium is over 23 million kilowatts per season, which is the equivalent of an entire year's energy consumption of 88,000 California residents in the United States (Glubiak, 2009). High energy use and non-renewable energy use in sports facilities are considered as an environmental problem, with attempts to overcome it by investing in environmentally friendly sports facilities (Kellison & Mondello, 2021). While energy consumption is considered as a separate environmental problem, the greenhouse gas carbon dioxide emission caused by this energy consumption represents another dimension of the problem.

Sports centres and stadiums are among the buildings that use non-renewable energy a lot, posing a major challenge for those responsible for overcoming this and investing in environmentally friendly facilities. Recent research in the field of sports management indicates that an increasingly popular option for building new

Reducing the carbon footprint in sports, whether it is organisational or based on facilities, can contribute to controlling a large part of the climate change problem (Schmidt, 2006). In this regard, the United Nations Climate Change Program has included the sports sector in its climate change action plans and determined the responsibility of the sports sector around the following objectives:

- Achieve a clear trajectory in tackling climate change in the global sports community through commitments and partnerships

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- Achieve a clear trajectory in tackling climate change in the global sports community through commitments and partnerships according to validated standards, including measuring, reducing and reporting greenhouse gas emissions;
- Using sport as a unifying tool to build unity and solidarity among global citizens for climate action (United Nations Climate Change, 2022).

It has developed an organisational management model in line with environmental sustainability targets in the Winter Games (Pizza, 2022). In the light of this management model, the Chinese Olympic Committee has determined and implemented environmental sustainability policies for the winter Olympic games. According to these policies:

- The Beijing Government has committed to a neutral carbon policy at the games and has taken measures to reduce carbon emissions, including low-carbon venues and transportation solutions.
- Under the heading of carbon compensation measures, the government carries out afforestation projects in the cities of Beijing and Zhangjiakou, where the games will be held, and has created 47,333 and 33,000 hectares of forest and green areas in Beijing and Zhangjiakou, respectively, since 2014.
- The Beijing government has committed to be the first Olympic Games to have venues powered by renewable energy, with solar and wind as primary energy sources, in the newly built Zhangbei region for the games.
- Under the heading of natural CO2 cooling systems, it has committed to use R449 refrigerant, which has a low Global Warming Potential threat, in ice hockey and curling halls in most of the ice fields in the games.
- Energy-efficient and clean-energy vehicles will make up 100 per cent of all passenger cars and 84.9 per cent of all vehicles. Beijing's 2022 fleet will include 816 hydrogen fuelled vehicles, 370 pure electric vehicles, 478 natural gas fuelled vehicles, 1,807 hybrid vehicles and 619 conventional energy vehicles (International Olympic Committee, 2022).

While many international organisations, especially the United Nations, take steps to solve environmental problems, the actors involved in sports are also attempting to be a part of this effort. Trendafilova et al., (2014) state that the sports industry is aware of the environmental problems in question and that it has set two goals within itself. These are to reduce the ecological footprint of sports and to increase the awareness of the participants about the importance of protecting the environment (Trendafilova et al., 2014). Within the sports sector, federations and especially sports clubs are taking steps to correct the negative relationship between sports and the environment.

A concerted effort is made in all sports leagues at the professional, college, and community levels to reduce the environmental impact of sports infrastructure in the United States. Since 2010, more than 30 professional clubs from the NFL, NBA, MLS and NHL (NRDC, 2012) and more than 50 universities nationwide have been developing environmental partnership programs in the construction and operation of sports facilities (NRDC, 2013). One of these programs is the greening of the sports infrastructure (Giulianotti, 2015). The understanding of greening the sports infrastructure aims to place the goals of eliminating environmental problems in sports management policies. In this way, it is aimed that the actors in the sports sector are both sensitive to environmental problems and financial savings (Trendafilova, et al., 2012; Anagnostopoulos, et al., 2014; Chen, et al., 2015). Green sports facilities, which have found quite a place in the literature in recent years and have been frequently the subject of research, protect the future of sports and the environment; has been put forward to realise the goal of a sustainable environment and facilities is to include environmentally friendly features (Trendafilova et al., 2014).

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Helps improve the quality of the environment: The sports centre's effort to meet certain environmental standards will promote smart location selection, water and energy use, more efficient use of local, recycled materials and resources, smart indoor environmental quality and overall innovative design (Porteshawver, 2009).

Helps improve infrastructure in the area where the facility is located: It has been argued that making sports facilities more environmentally friendly improves a city's infrastructure in ways that traditional sports centres cannot offer (Porteshawver, 2009).

New job opportunities can be created: Building green sports centres can also create job opportunities in environmental areas and stimulate regional and local growth (De Mause, and Cagan, 2008, p. 67).

Energy Costs of Facilities can be reduced: Energy efficient buildings can save ten to twenty per cent in operating costs, including electricity cost, waste disposal and management, water and building maintenance (Baum, 2009, p. 113).

It can increase sponsor and fan revenues: A club image with a high awareness of environmental sustainability can provide sponsor revenues from different sectors and increase the support of the fans (Porteshawver, 2009).

CONCLUSION

In this research, since the carbon footprint of energy (electricity and natural gas) used in the heating and lighting of 2 sports complexes in the university campus will be calculated, only the information and values in the energy heading were used. The actors of sports have important responsibilities in the prevention of carbon footprint originating from the sports sector and in the construction of a sustainable environment. It is important to build and expand green sports facilities, especially for future generations to benefit from all the benefits of sports in a liveable environment. For this:

Renewable energy sources can be reached to meet the energy needs of sports facilities.

The use of recyclable materials in the construction of sports facilities can help control natural resource consumption.

The awareness level of those who are injured from sports facilities, both actively and passively, about increasing environmental problems can be increased. In this way, waste production can also be brought under control.

The fact that sports facilities managers are more sensitive about the relationship between the environment and sports and improve their awareness level can facilitate this whole process.

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Conflict of Interest Statement

There is no personal or financial conflict of interest between the authors of the article within the scope of the study.

Researchers' Contribution Rate Statement

As the author of this study, all contributions and responsibilities in the research design, data collection, analysis and preparation of the article belong to me.

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