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An evaluation of the carbon footprint problem in winter sports: Carbon footprint of Sarıkamış Ski Facilities

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A B S T R A C T

Purpose: The purpose of the present study, which was based on the increasing relationship between sports and the environment and the importance of this relationship, was to calculate the carbon footprint of Sarıkamış Ski Facilities in the city of Kars, Turkey. To do this purpose, an answer was sought to the following study question: *What is the carbon footprint of Sarıkamış Ski Facilities?*

Methodology: The study was conducted within the scope of quantitative research methods design, which are used frequently in social sciences in recent years. The amount of electricity consumed on the cable car line in Sarıkamış Ski Facilities in Kars and the natural gas consumption amounts of the three hotels that have the highest bed capacity and overnight stays in the hotels area were used as the dataset in the study. To answer the study question, the carbon dioxide emission amount (carbon footprint) of the ski Facilities was calculated by using the calculation methodology (Tier 1 Method) that was put forward by the Intergovernmental Panel on Climate Change (IPCC).

Results/Findings: The carbon dioxide emission (carbon footprint) occurring because of the natural gas consumption of three accommodation facilities and the electricity consumption of the cable car lines on the ski slopes in the 2022 ski season in Sarıkamış Ski Facilities was calculated as 12.140.58 tons. According to these calculations, 86% of the carbon footprint of the ski facilities occurred because of electricity consumption. This can be associated with the increasing demand in Sarıkamış Ski Facilities and the intense use of cable car lines to cover this demand. These results, which were limited to Sarıkamış Ski Facilities in Kars in Turkey, indicate that it is necessary to turn to renewable energy sources in Sarıkamış Ski Facilities. Also, it can be argued that the increasing demands on skiing should be covered in an environmentally friendly manner with increasing awareness of environmentally friendly energy. It is inevitable to develop sustainable environmental and sports policies to resolve environmental problems such as climate change, global warming, and carbon footprint. This study, which was limited to only Sarıkamış Ski Facilities, is expected to prepare the ground for a study throughout Turkey, and it is also aimed to help the development of an environmentally friendly sports concept in Turkey.

A R T I C L E I N F O

Keywords: *Climate Change, Carbon Footprint, Sports, Winter Sports, Sports Facilities.*

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1. INTRODUCTION

It is already known that the attitudes and behaviors of people with the acceleration of social life cause negative environmental consequences. Especially the rapid increase in urban population, urbanization, and the increasing and diversified consumption need also increase the pressure on natural resources and their use accelerates. This brings with it global climate problems, climate changes, and ultimately, global warming (Özsoy, 2015). Climate change probably represents the greatest difficulty facing humanity this century (Eichinger, 2019). It is also known to have complex consequences for the environment, society, economy, and human health (Townsend et al., 2003). Especially the destruction of the living environment by the people threatens the sustainable environmental targets. Climate change, global warming, carbon footprint, etc. environmental problems are frequently discussed in recent years and scientific studies are conducted on solution proposals. Dolf and Teehan (2015) reported that climate change problems that emerged from people's attitudes and behaviors may cause social, economic, and ecological deterioration in the future. It was stated in the report of the Intergovernmental Panel on Climate Change (IPCC) (2007) that greenhouse gas emissions caused by human activities increased rapidly in recent years and this threatened the environment and natural resources. To do this reason, increasing environmental problems and environmental sustainability concerns have become one of the most important problems faced by societies in the entire world (Shahroh et al., 2020). It is now known that the carbon footprint is at the forefront of these human-induced environmental problems

1.1. Carbon Footprint Concept

Carbon footprint is defined as the measure of the damage caused by human activities to the environment in terms of the amount of greenhouse gas produced and is measured in a unit of carbon dioxide (Atabey, 2013: 84). In other words, carbon footprint defines environmental pollution, greenhouse gas, and carbon dioxide emissions caused by people, institutions, businesses, and organizations, and expresses a dimension of environmental problems (Global Footprint Network, 2017). The attitudes and behaviors of people and the activities they are engaged in gradually intensified in developing societies. This has enlarged the carbon footprint of societies, and the natural environment and resources were then destroyed. Especially the carbon footprint of mass human behavior is increasing with each passing day.

1.2. Carbon Footprint in Sports

Sports are among the areas where mass interest and participation are most intense. Participation in professional, amateur, or touristic sports is increasing with each passing day, human activities are intensifying, and this is increasing the sports-induced carbon footprint problem. Pereira et al. (2019) stated that the negative environmental effects caused by sports are gradually increasing, and draw attention to the fact that the carbon footprint is growing and measures must be taken in the sports sector. As a matter of fact, in our present day, when sports and the environment are considered together, the increase in participation in sports, the consumption of natural resources, and the problems faced in waste recycling deepen the relationship between sports and environmental problems, and this makes the carbon footprint problem more evident in sports (Pfahl, 2013; Collins et al., 2009; Bunds and Casper, 2014).

The increasing negative relationship between sports and the environment has mobilized countries on a global scale. Especially the carbon footprint problem that stems from sports started to be discussed frequently in academia. Countries also started to set targets and prepare research reports for the reduction of carbon footprint in sports at the level of governments. In this respect, the Italian Association of Sports for All prepared a report and conducted a systematic analysis of the carbon footprint in sports. According to this report, the carbon footprint is grouped under two headings in sports, which are; the establishment in sports and sports events and organizations. The evaluations in this report are presented in the image below (Sorrentini, 2021).

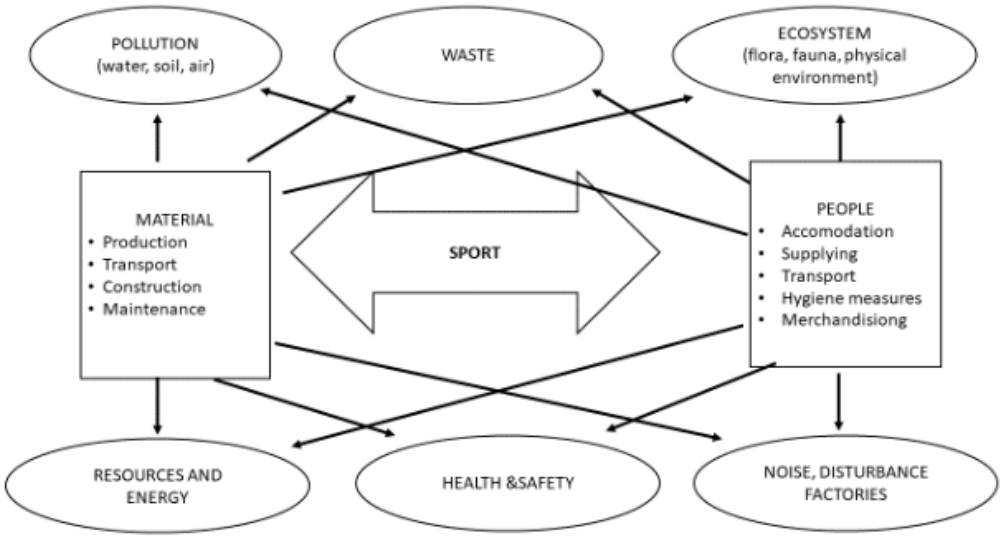

Figure 1: Systematic analysis of the carbon footprint in sports

In the image given above, the sources of carbon footprint in sports are interpreted under two main headings. The first of these is the negative environmental effects caused by sports facilities and the maintenance and repair of existing facilities. The second one is the negative environmental effects caused by participation in organized sports events and organizations.

Reasons such as the construction of new sports facilities, maintenance and repairs of existing facilities, and high energy use in these facilities trigger the emergence of carbon footprints that stem from sports. Ski and accommodation facilities that host winter sports cause high energy use, which can reveal negative environmental effects. In ski facilities, the use of high amounts of electrical energy on cable car lines and the supply of heating needs of accommodation facilities based on fossil fuel sources such as natural gas associates the carbon footprint problem with sports. Mountainous areas where winter sports, especially skiing, are practiced are known to be sensitive areas for climate change and environmental problems (Burki et al., 2003). This vulnerability includes the declined quality of natural resources such as air and water, and damage to habitat and species (Mansfield, 2009).

1.3. Kars Sarıkamış Ski Facilities

The city of Kars is located in the Erzurum-Kars Part of the Eastern Anatolia of Turkey. There is Ardahan in the North, Armenia in the East, cities of Iğdır and Ağrı in the South, and Erzurum in the West. The population of the city is 284.923 and 50.8% of this population lives in the city center. The area of the city is 10.193 km². There are 28 people per km² in the city. The city has 8 districts, 9 municipalities, 57 neighborhoods, and 381 villages in municipalities. One of the 8 districts is Sarıkamış in Kars (http://kars.gov.tr/tarih). The most important characteristic distinguishing Sarıkamış from other districts is that it has one of the largest and most important ski facilities in Turkey. The Cıbıltepe Ski Center, which is located in the South of Sarıkamış Ski Facilities, was declared Kars Sarıkamış Süphan Cıbıltepe Balıkdağ Çamurludağ Tourism Center on the Official Gazette on 20.05.1991 with the number 20876. Boundary changes were made in this tourism center in 1993, 2005, and 2006. In the Official Gazette on 26.07.2010 with the number 27653, the name was changed to Kars Sarıkamış Winter Sports Tourism Center and reached its current status and borders (Çalışkan, 2014:45). There are accommodation establishments with various stars and characteristics in Kars Sarıkamış Winter Sports and Tourism Center. There are a total of 16 accommodation facilities with "Tourism Operation Certificate" in Sarıkamış (Çelik and Gelibolu, 2019).

Powder crystal snow, which is very suitable for skiing and is only found in the Alps in the world, is only found in the Sarıkamış area in our country. Having one of the longest ski slopes in the world and called "Turkey's Insburg", Sarıkamış Ski Facilities are among the characteristics that distinguish them from other facilities, primarily the type and rate of snow falling in the area. Crystal snow, which is only found in the Alps, aside from Sarıkamış, is extremely suitable for skiing. The total track length is 25 km in this ski facility. The tracks have 2 stages and there are 5 tracks from the summit to the 1st stage, and 2 tracks from the 1st stage to the bottom. Also, it descends to 2 trails called "the Dark Creek" from the summit. There is also a 200-meter half-pipe (snowboard) track in this area (http://www.sarikamis.gov.tr/sarikamis-kayak-merkezi).

1.4. Purpose of the study

The purpose of the present study, which was based on the increasing relationship between sports and the environment and the importance of this relationship, was to calculate the carbon footprint of Sarıkamış Ski Facilities in Kars. To do this purpose, the answer was sought for the following study question.

- What is the carbon footprint of Sarıkamış ski facilities?

1.5. Limitations of the Study

According to the official records, there are 16 amateur and professional ski facilities in Turkey. These facilities host competitions for professional athletes and domestic and foreign tourists interested in skiing as an amateur. The study was limited to Sarıkamış Ski Facilities in Kars city because of limited time and data collection opportunities. Also, the bed capacity and the number of overnight stays were limited to a maximum of three accommodation facilities to measure the carbon footprint because of natural gas consumption in Sarıkamış Ski Facility.

2. METHOD

2.1. Methodology of the Study

The study was conducted in the scope of quantitative research methods used frequently in social sciences in recent years. The amount of electricity consumed on the cable car line in the Sarıkamış Ski Facility in Kars and the natural gas consumption amounts of the three hotels that have the highest bed capacity and overnight stays in the hotels area were used as the dataset. To answer the study question, the carbon dioxide emission amount (carbon footprint) of the ski facility was calculated by using the calculation methodology (Tier 1 method) put forward by the Intergovernmental Panel on Climate Change (IPCC). The IPCC Method groups emission calculation methods under three headings, which are evaluated in 3 different categories called Tiers (Binboğa & Ünal, 2018). The Tier 1 Method requires less and simple data in general, Tier 2 and 3 methods are complex calculation methods that require more data (Atabey, 2013: 45). To calculate the carbon footprint of 2 sports complexes with the Tier 1 calculation method, the carbon footprint that results from the electricity and natural gas consumption used for lighting and heating in the sports complexes was calculated.

2.2. Data Collection Process

The amount of electricity consumed on the cable car line in the ski center during December and March was obtained from the Kars Special Provincial Administration to calculate the carbon footprint of Sarıkamış Ski Facilities in the 2022 ski season. Also, the natural gas consumption amounts of the 3 hotels that had the highest number of beds and overnight stays in the hotels area were obtained from the relevant management units of the hotels. The total amount of natural gas and electricity consumed in Sarıkamış Ski Facilities during the ski season is presented in the table below.

Table 1: The consumption amounts of electricity and natural gas for the December-March 2021 period

Energy Type	**Consumption Amount (Cubic Meters)**	**Consumption Amount* (Tons)**	**Consumption Amount (Gigagram)**
Natural Gas	793.000	634.321	634.321
Electricity	17.878,57 KWh		

**** Converted to tons and gigagrams by multiplying densities according to energy types.***

According to the density of natural gas;

1 m^3 =0.7999 t

1 t = 10^{-3} Gg= 0.001 Gg

The analysis process of the data obtained in this study consisted of two stages, which were the calculation of the carbon footprint because of electricity consumption and the calculation of the carbon footprint because of natural gas consumption. The IPCC carbon dioxide emission factor of 0.584

tons/mWh was used in the calculation of the carbon footprint caused by the electrical energy consumed in the cable car line in the ski facility (Toroz, 2015, p. 79). The formula given below was used to calculate the carbon footprint because of electricity consumption (Binboğa and Ünal, 2018).

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

The carbon footprint calculation process based on natural gas used in covering the heating needs in hotels consists of four steps. The energy consumption is calculated in the first step depending on the amount of natural gas used, 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 measuring the carbon footprint of the sports complexes (Binboğa and Ünal, 2018). Detailed information and calculation methods regarding the calculation in these four steps are given below.

First Step

Firstly, it is necessary to calculate the amount of natural gas-based energy consumption in hotels. The total fuel consumption is multiplied by the net calorific value in the calculation of this energy amount. To do this, the formula given below was used (Binboğa and Ünal, 2018).

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

The net calorific values of the fuel types are those included in the "Manifesto on Monitoring and Reporting of Greenhouse Gas Emissions" published in the Official Gazette on 22.07.2014 with the number 29068 and specified in the IPCC 2006 Guideline (Binboğa and Ünal, 2018). These values are presented in the table below.

Table 2: Net calorific values according to fuel types

Fuel Type	**Net Calorific Value (TJ/Gg)**
Benzine	44.3
Diesel	43.0
LPG (Liquefied Petroleum Gas)	47.3
Lignite Coal	11.9
Natural Gas	48.0

Second Step

The carbon content for the natural gas used in the hotels is calculated in the second step. To do this, the calculation is made by multiplying the carbon emission factor specified in the IPCC Guideline with the energy consumption value calculated in the first step. The formula given below was used to do this calculation (Binboğa and Ünal, 2018). Also, the emission factors of the fuels given in the IPCC Guideline are presented in the table below.

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

Table 3: Emission factors according to fuel types

Fuel type	**Emission Factor (t C/TJ)**
Benzine	18,90
Diesel	20,20

LPG (Liquefied Petroleum Gas)	17,20
Lignite Coal	27,60
Natural Gas	15,30

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

Third Step

It is necessary to calculate the carbon emission for the natural gas used in the hotels in the third step. To do this, the carbon content value found in the second step is multiplied by the oxidation rate of the fuels. Considering the oxidation percentage (i.e. combustion efficiency) values of the fuels according to the IPCC, the value for gaseous fuels (Natural Gas) is 0.995. The formula given below was used to do this calculation (Binboğa and Ünal, 2018). Also, the oxidation rates of the fuels given in the IPCC Guideline are presented in the table below.

$$\textit{Carbon Emission (Gg C) = Carbon Content (Gg C) × Carbon Oxidation Rate}$$

Table 4: Oxidation rates according to fuel types

Fuel Type	**Oxidation Ratio**
Benzine	0.99
Diesel	0.99
LPG (Liquefied Petroleum Gas)	0.99
Lignite Coal	0.98
Natural Gas	0,995

Source: Manifesto Amending the Manifesto on Monitoring and Reporting of Greenhouse Gas Emissions, 2014.

Fourth Step

The carbon dioxide emission for the natural gas used in the hotels is calculated in the fourth and last step. To do this, the ratio of the molecular weight of carbon dioxide to the molecular weight of carbon is used. This ratio is 44/12. At this step, the carbon emission value calculated in the third step is multiplied by the 44/12 value (Binboğa and Ünal, 2018). The natural gas-sourced carbon footprint of the sports complexes will be calculated at the end of these four steps. To do this, the formula below was used (Binboğa and Ünal, 2018).

$$\textit{CO2 Emission (Gg } CO_2\textit{) = Carbon Emission (Gg C) × (44/12)}$$

When the study that was conducted by Binboğa and Ünal (2018) was considered, the formula and steps of carbon footprint calculation were followed in this study, and these steps were explained in detail. The calculation methods and formulas used in the study were reduced to a single formula by the researcher. The formula compiled by the researcher to be used in carbon footprint studies in the sports sector is given below.

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

3. FINDINGS

In this part of the study, the findings on the carbon footprint calculated based on natural gas and electricity consumption in the 2022 ski season in Sarıkamış Ski Facilities in Kars are included.

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Energy Type	Consumption Amount (Cubic Meters)	Consumption Amount (Tons)	Consumption Amount (Gg/C)	Net Calorific Value (TJ/Gg)	Energy Consumption (TJ)	Carbon Emission Factor (tC/TJ)	Carbon Content (Ton)	Carbon Content (Gg/C)	Carbon Oxidation Ratio	Carbon Emission (Gg/C)	Carbon Emission Value	CO_2 Emission (Gg/C)	CO_2 Emission (t)
Natural Gas	793.00	634.321	634.3207	48.0	30.447.41	15.3	465.845.37	465.84	0.995	463.51	44/12	1699.53	1.699.5
Electricity	17.878.57 KWh												10.441.08
Total													12.140.58 CO_2

The natural gas consumption of three accommodation facilities and the carbon dioxide emission (i.e. carbon footprint) because of electricity consumption in the cable car lines on the ski slopes were calculated as 12.140.58 tons in the 2022 ski season in Sarıkamış. According to the calculations, 86% of the carbon footprint of ski facilities occurred because of electricity consumption. This can be associated with the increasing demand in Sarıkamış Ski Facilities and the intense use of cable car lines to cover this demand.

4. CONCLUSION

In the present study, in which the carbon footprint occurring because of electricity and natural gas use in Sarıkamış Ski Facilities in Kars city is calculated, the results of the relationship between sports and the environment in Sarıkamış scale have been tried to be shared. Since there is not enough research on the measurement of the carbon footprint of ski facilities, the discussion part of the study is not only related to the ski facilities but also the negative environmental effects of sports facilities in general.

The natural gas consumption of three accommodation facilities and the carbon dioxide emission (carbon footprint) because of electricity consumption in the cable car lines on the ski slopes were calculated as 12.140.58 tons in the 2022 ski season in Sarıkamış. According to the calculations, 86% of the carbon footprint of ski facilities occurred because of electricity consumption. This can be associated with the increasing demand in Sarıkamış Ski Facilities and the intense use of cable car lines to cover this demand. The fact that the ski facilities that host winter sports use high amounts of energy because of the increasing demand and that this energy need is supplied from fossil fuels might cause the carbon footprint to occur and grow in the ski facilities. The consumption of fossil fuel energy from known sources such as oil, coal, and natural gas causes greenhouse gas emissions, which in turn, causes air pollution (Chard and Mallen, 2013).

As in other sectors of society, it is necessary to deal with the environmental problems emerging in the sports sector and to reduce the environmental damage. When sports cause negative environmental effects, they can also be affected by these negative effects directly. The most obvious problem faced in winter sports is the shortening of the snow season in the areas where ski facilities are located because of climate change. A high amount of energy is required for artificial snow production in ski facilities because of the shortening of the snow season, which causes environmental problems (Scott et al., 2003). The fact that the energy need is mostly covered by fossil fuel sources causes carbon dioxide emissions, and for this reason, the carbon footprint stemming from winter sports is growing. Adverse environmental effects caused by facilities hosting sporting events are of particular concern (Taks, 2013; McCool, 2015). Even the infrastructure system in the areas where the facilities are located can be a determining factor in these negative effects (Triantafyllidis et al., 2018). Balcı and Koçak (2014), who reported the important negative consequences of covering the electrical energy used in the cable car lines in the ski facilities and the heating needs of the accommodation facilities with natural gas, list the negative environmental impacts of the ski facilities in general as follows.

- Destruction of the natural vegetation
- Deterioration and scarcity of the integrity of protected forests
- Soil compaction

- Chemical pollution in the soil because of fuel leaks
- Landslide, soil erosion, avalanches
- Use of forest lands for infrastructure and superstructure works (i.e. parking areas, roads, hotels, etc.)
- Solid waste generation
- Noise pollution
- Deterioration in wildlife (Balcı and Koçak, 2014).

Environmental problems and climate change are accepted as serious problems on a global scale and it is expected that the actors will be involved in this problem, especially in sports (Winn et al., 2011). It can be accepted that the sports sector is responsible for the pollution of the environment and the consumption of natural resources because of the establishment and participation in sports events. Steffen et al. (2015) reported that the main factor causing climate change by disrupting the natural balance is human behavior the center of which is the human being. Intense mobility, mass participation, and the steps to cover these participations show the negative relationship between sports and environmental impacts.

The increased demand for winter sports creates the need for more electricity and natural gas in ski facilities. Negative environmental impacts are deepening, especially because of carbon dioxide and greenhouse gas emissions. To prevent these growing environmental problems, the United Nations Climate Change program prepared a Climate Action Plan for sports and put into effect the following 5 principles regarding the measures to be taken.

- Undertaking systematic efforts to promote greater environmental responsibility;
- Reducing overall climate effects;
- Education on climate action;
- Promoting sustainable and responsible consumption;
- Advocating for climate action through communication (Sports for Climate Action Framework).

Only governments or international organizations are not responsible for the carbon footprint problem that is caused by sports facilities and events. Also, sports managers, participants, academics, and all stakeholders in the sports industry have responsibilities to address environmental issues (Sartore-Baldwin and McCullough, 2017). For this reason, sports administrators and sports science departments of universities are taking increasing responsibility for climate change issues because they aim to improve the environmental sustainability of events and include this message in the reach of stakeholders (Mallen et al., 2010). Also, sports clubs produce various plans and policies to combat the negative environmental effects of sports. In our present day, many sports clubs offer bicycle parking, alternative transportation, or public transportation support among their sustainable transportation efforts. Also, hybrid or fuel-efficient vehicles are preferred in this respect. Initiatives related to stadiums or facilities include the

certification for LEED, solar or wind power, energy-efficient signage, and measures to conserve water (Blankenbuehler and Kunz, 2014).

When studies are being conducted across the federations, the Federation Internationale de Ski (FIS) announced that it has taken steps towards becoming the first Climate Positive International Sports Federation by 2022 through the "Rainforest Initiative" by creating an environmentally friendly action plan. With this project, FIS aims to balance its carbon footprint on a global scale with its Rainforest Protection Project. As part of this project, FIS also aims to perform an internal carbon footprint audit of competitions throughout the entire ski season. Based on data from the organizers, the FIS aims to estimate the overall carbon footprint of thousands of ski events and take action to reduce the climate effects of these events (https://www.fis-ski.com/en/international-ski-federation/news-multimedia/news-2022/fis-set-to-become-first-climate-positive-winter-sport).

It can be argued that environmental sustainability concerns of all stakeholders of the sports industry are common. Clubs and federations work in line with sustainable environment and sports goals and try to take the necessary measures. The dynamism of the sports sector and the increasingly active and passive participation with each passing day increase the concerns about negative environmental effects. The results of the study, which was limited to Sarıkamış Ski Facilities in Kars in Turkey, indicate that it is necessary to turn to renewable energy sources in Sarıkamış ski facilities. It can also be argued that the increasing demands on skiing should be covered in an environmentally friendly manner with increasing awareness of environmentally friendly energy. It is inevitable to develop sustainable environmental and sports policies to solve environmental problems such as climate change, global warming, and carbon footprint. The present study, which was limited to only Sarıkamış Ski Facilities, is expected to prepare the ground for a study to be conducted throughout Turkey, and it was also aimed to help the development of an environmentally friendly sports concept in Turkey.

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