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Zonguldak Bulent Ecevit University Farabi Campus 2023 Carbon Footprint Analysis and Sustainable Solution Proposals

Zonguldak Bülent Ecevit Üniversitesi Farabi Kampüsü 2023 Yılı Karbon Ayak İzi Analizi ve Sürdürülebilir Çözüm Önerileri

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Abstract

The reduction of emissions and reaching carbon neutrality are implemented by various organisations, institutions, countries, and other associations on national and international levels. Universities are central to promoting sustainability and modelling low-carbon practices. This study assesses the 2023 carbon footprint (CF) of Zonguldak Bülent Ecevit University's Farabi Campus, aiming to quantify its greenhouse-gas impacts, highlight mitigation opportunities and encourage more prudent resource use. Emissions from natural gas, electricity, water and campus-fleet vehicles were estimated using IPCC and UK DEFRA factors. Total emissions reached 2 361.24 t CO_2e (IPCC) and 1 697.35 t CO_2e (DEFRA); the per-person CF, calculated for all staff as of December 2023, provides an additional benchmark. Interpreting these results clarifies current impacts and helps prioritise actions needed to meet the university's carbon-neutral ambitions. Recommended measures—such as improving energy efficiency, adopting sustainable transport, and strengthening waste-management and offset programmes—offer a practical roadmap for reducing emissions and advancing campus sustainability. The results of the study provide important information for the campus management as a basic guide to determine the steps to be taken for a carbon-neutral campus. In this context, recommendations such as energy efficiency measures, sustainable transportation policies, waste management strategies, etc. contribute to a sustainable future for the campus.

Keywords: Carbon footprint, Climate change, Green campus, Sustainability

Özet

Emisyonların azaltılması ve karbon nötrlüğüne ulaşılması, ulusal ve uluslararası düzeylerde çeşitli kuruluşlar, kurumlar, ülkeler ve diğer birlikler tarafından uygulanmaktadır. Üniversiteler, sürdürülebilirliği teşvik etme ve düşük karbonlu uygulamalarda model olma açısından önemli bir rol oynamaktadır. Bu çalışma, Zonguldak Bülent Ecevit Üniversitesi Farabi Kampüsü'nün 2023 yılına ait karbon ayak izini değerlendirerek sera gazı etkilerini nicel olarak belirlemeyi, azaltım fırsatlarını ortaya koymayı ve doğal kaynakların daha sürdürülebilir kullanımını teşvik etmeyi amaçlamaktadır. Doğalgaz, elektrik, su tüketimi ve kampüs araç filosundan kaynaklanan emisyonlar IPCC ve Birleşik Krallık DEFRA metodolojileri kullanılarak hesaplanmıştır. Toplam emisyonlar IPCC'ye göre 2.361,24 ton CO_2e, DEFRA'ya göre ise 1.697,35 ton CO_2e olarak hesaplanmıştır. Bu veriler, üniversitenin karbon nötr hedeflerine ulaşmasında öncelikli adımların belirlenmesine yardımcı olmaktadır. Enerji verimliliği, sürdürülebilir ulaşım ve atık yönetimi gibi önlemler, emisyonların azaltılmasına katkı sağlar. Çalışmanın sonuçları, kampüs yönetimi için karbon nötr bir kampüs oluşturmak için atılacak adımları belirlemede temel bir rehber olarak önemli bilgiler sağlar. Bu bağlamda, enerji verimliliği önlemleri, sürdürülebilir ulaşım politikaları, atık yönetimi stratejileri vb. gibi öneriler, kampüs için sürdürülebilir bir geleceğe katkıda bulunmaktadır.

Anahtar Kelimeler: İklim Değişikliği, Karbon Ayakizi, Sürdürülebilirlik, Yeşil Kampüs

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1. Introduction

University campuses are living centers where all kinds of socio-cultural activities take place throughout the students' educational lives and where students spend most of their time. As a result of these activities, atmospheric greenhouse gas levels on campuses will inevitably increase. One of the most common approaches to determining greenhouse gas emissions is the "carbon footprint". Carbon footprint is an indirect representation of the carbon dioxide and other greenhouse gasses released into the atmosphere as a result of an organization's or individual's activities. In this context, greatly reducing the carbon footprint has become the focus of environmental policies worldwide (Bajzelj et al., 2014; Ward et al., 2016). In order to develop carbon footprint reduction strategies, sectoral and institutional emission calculations currently depend on complete, accurate and transparent calculations (Gao et al., 2014).

What global climate change will create on our planet; Realizing the negative consequences such as species extinction, sea level rise, temperature increase, desertification, drought, endangering food security, epidemics, floods and hurricanes, the United Nations Framework Convention on Climate Change was established in 1992 and then Kyoto in 1997, in order to reduce the emission of greenhouse gasses. The protocol was created (Binboğa and Ünal, 2018). Developed by the United Nations General Assembly in 2015, the Sustainable Development Goals (SDGs) provide clear guidelines and targets for all countries to adopt in line with their priorities and the world's environmental challenges. Goal 13 of the Sustainable Development Goals focuses specifically on the need to address climate change.

To combat the adverse effects of climate change, Goal 13 includes five targets; One of these is to raise the awareness of institutions and people about mitigating climate change and improve their ability to do so. Setting goals and targets within the scope of the Sustainable Development Goals is a positive step towards better educating the young generation about sustainability and environmental impacts (Yanez et al., 2019).

Universities are being challenged to take the lead on sustainability concerns because of their significant social influence. Compared to other societal sectors, universities may have a considerably bigger impact on sustainable development (SD) while also training the next generation of influencers and decision-makers. The environment and university sustainability initiatives are particularly important to understand because students are influential changemakers in their communities. One social behavior commitment that

exemplifies environmental sustainability practices is the reduction of carbon footprints in university settings (da Silva et al., 2023).

Over the past 50 years, higher education institutions around the world have gradually implemented sustainability policies focused on improving their environmental indicators and corporate image. One of the sustainability-related issues that is receiving increasing attention from these organizations is Climate Change, which is reflected in the increasing number of Greenhouse Gas (GHG) inventories of an organizational nature. (Varón-Hoyos et al., 2021).

The main greenhouse gasses that cause climate change are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbon (HFC), perfluorocarbon (PFC) and sulfur hexafluoride (SF6). The most important of these components is CO2 gas, and its share in total greenhouse gasses is around 80%. Since these gasses trap heat, more heat is absorbed as the greenhouse gasses in the atmosphere increase, which causes global warming. Greenhouse gasses resulting from rapidly developing industrialization negatively affect life on Earth with the climate change caused by the rapid increase in global warming (Alagöz et al., 2022).

All segments of society must act with this awareness to achieve success in the fight against global climate change. In this context, universities, non-governmental organizations, private sector organizations, public institutions, and citizens need to be sensitive to this issue and take an active role in the sustainable use of natural resources by assuming responsibility. In this context, universities, as the leading institutions of society that produce and disseminate science, need to determine their strategies by revealing the steps they will take to combat global climate change (Binboğa and Ünal, 2018).

The concept that environmental problems have come to the fore most frequently in recent years is global climate change. Particularly noteworthy is the increasing trend in carbon dioxide (CO_2) emissions caused by human activities, which is shown as one of the causes of global climate change. In this context, the amounts of carbon emissions released by individuals and institutions have begun to be calculated with the methods created by the Intergovernmental Panel on Climate Change (IPCC), which deals with climate change (IPCC, 2006; IPCC, 2013; IPCC, 2022). The UK Department for Environment, Food and Rural Affairs (DEFRA) coefficients aim to protect, support and ensure sustainability of the natural environment. This institution carries out studies in terms of sustainability, especially within the scope of global warming and greenhouse gas emissions. In order to carry out these studies, it regularly publishes carbon emission coefficients in a wide range of areas such as

all emission gasses, transportation vehicles, food consumption and all energy consumption every year. Carbon footprint is calculated taking into account the coefficients published by DEFRA (Çerçi, 2021).

Carbon neutrality is the net-zero balance of greenhouse gas emissions in a given system. Achieving this goal involves, firstly, calculating and managing its emissions, and secondly, mitigating these impacts. Supporting these objectives requires an appropriate measurement tool: a carbon footprint, which serves as a record of emissions calculation or inventory (Kiehle et al., 2023). Furthermore, apart from carbon dioxide, other greenhouse gasses typically encompass methane, nitrous oxides, and fluorocarbons (HFCs and PFCs) (IPCC, 2014). To incorporate these, emission inventories commonly employ the concept of 'CO2 equivalents' (CO_2e). Such an assessment's outcome helps identify primary emission sources, serving as a starting point for planning effective reduction measures for greenhouse gas emissions. Additionally, it can be utilized to monitor progress in reduction efforts, thereby aiding in tracking climate-related goals and action plans. Both matters highlight the significance of the carbon footprint as a crucial tool in the journey towards carbon neutrality (Awanthi and Navaratne, 2018). Although guidelines currently exist for calculating the corporate-level carbon footprint, standards have not been specifically tailored to the needs of higher education institutions. Robinson et al. (2018) have noted that universities fundamentally differ from corporations in terms of their functions and the infrastructure required to fulfill them. An environment for teaching and learning requires resources different from those of a service or industrial sector company. Considering the unique characteristics of universities compared to corporations, it is necessary to adopt more general standards. In recent years, many universities have addressed this issue by developing their methodologies and offering different approaches (Kiehle et al., 2023).

As the Greenhouse Gas Protocol Corporate Standard serves as the primary guideline, the criteria for emissions to be incorporated into Scopes 1 and 2 are explicitly outlined. Nonetheless, the criteria for Scope 3 are not as stringent, allowing for the discretionary adoption of specifically chosen indirect, non-energy-related emissions. It appears that universities determine which emissions to integrate into their ultimate carbon footprint based on their expertise. Given the nature of higher education institutions, Scope 1 may encompass the fuel usage of the university's vehicle fleet and certain emissions resulting from the direct combustion of fossil fuels on campus. Scope 2 may include purchased electricity, (regional) heat, water consumption, and, if relevant, purchased (regional) cooling (Kiehle et al., 2023; WRI, 2004).

Within the framework of these responsibilities, all institutions need to calculate and try to reduce the carbon footprint, which is the amount of damage caused by human activities to the environment, measured in units of carbon dioxide or carbon. With this study, emission sources within the borders of the BEUN (Zonguldak Bülent Ecevit University) Farabi campus, natural gas consumption due to heating, electricity consumption, water consumption, fuel consumed by central campus garage vehicles, fuel consumed by vehicles in the shuttle transportation network, bus-plane travel of personnel going to domestic and international duties were examined. It was determined as the fuel consumed and the fuel consumed by the personnel coming to the institution with their private vehicle. As the calculation method for numerical data, the methodologies of the Intergovernmental Panel on Climate Change (IPCC) and the UK Department for Environment, Food and Rural Affairs (DEFRA) were used. Calculation and evaluation of the carbon footprint, determination of measures to reduce the carbon footprint, education/awareness. It aims to carry out studies and contribute to the more sustainable use of natural resources.

2. Material and Method

2.1. Study Area

The Zonguldak Bülent Ecevit University Farabi Campus is situated in Northern Turkey (Fig. 2) and had 973 staff members in 2023. Zonguldak Bülent Ecevit University (BEUN) operates across 12 campuses located in Zonguldak city center and its districts. The total land area of our university is 245.01 hectares. Of this, 234.24 hectares consist of allocated land, while 10.78 hectares are owned by the university. Two main campuses are situated in the city center of Zonguldak. One of them is the Medical Faculty and is located near the hospital in İbni Sina Campus, while the other faculties are based on the Farabi Campus. BEUN offers educational programs at all levels in fields such as technology, education, medicine, and science. In addition to two large campus areas in the center of Zonguldak, there are also several small research units affiliated with BEUN in different regions of Zonguldak. The boundaries of this study were the physical boundaries of BEUN Farabi Campus. The research focused on specific locations and features within the campus, including classrooms, library, cafeterias, and other student services. Areas outside the campus or activities elsewhere were beyond the scope of this study and were not analyzed. This limitation aimed to clarify the focus area of the study, ensuring more precise and meaningful results. Figure 1 displays an aerial view map of the Farabi campus.

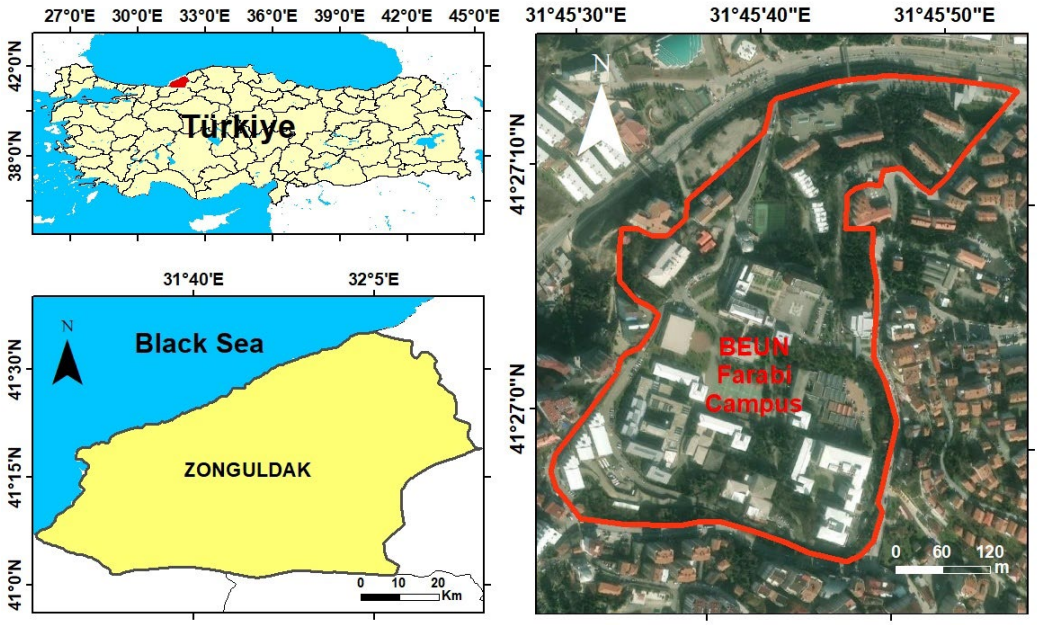

Figure 1. BEUN Farabi Campus Site Map.

2.2. Identification of Emission Sources and Data Collection

In this study, emission sources were calculated taking into account the vehicles, heating, and electricity consumption associated with Zonguldak Bülent Ecevit University's Farabi Campus. Factors such as the heating fuel type and consumption amount in buildings such as staff quarters, cafeteria, nursery, as well as the amount of electricity and water consumption in 2023, the type and amount of fuel consumed by campus garage vehicles, the number, type, routes (along with the distance traveled in km) of vehicles in the shuttle transportation network, and information about the fuel type of these vehicles were determined. Data was requested from relevant departments with a cover letter, and information for the year 2023 was obtained (Table 1).

Table 1. Fuel, electricity, and water consumption data of BEUN in 2023.

Scope 1			**Scope 2**	
Natural Gas (m^3)	**Gasoline (lt)**	**Diesel fuel (lt)**		**Water (m^3)**
455894.0	10197.84	21793.6	2646610.6	28546.0

2.3. IPCC Scope-1 Methodology

The Tier 1 method is fuel-based because emissions from all combustion sources can be estimated based on the quantities of fuel burned (typically from national energy statistics) and average emission factors. Tier 1 emission factors are available for all relevant direct greenhouse gasses. Emission factors for CO_2 are primarily dependent on the carbon content of the fuel, so CO_2 emissions can be estimated quite accurately based on the total quantity of fuel burned and the average carbon content of the fuels (IPCC, 2006).

CO_2 emissions for all emission sources can be calculated by summing the products of the Activity Data (AD) and the Emission Factor (EF) using the following formula:

$$CF=\sum ADxEF$$

Where,

i represents the number of emission sources.

AD stands for Activity Data, which quantifies an activity in units that can be combined with the emission factor.

EF represents the Emission Factor, which is the value used to scale emissions to activity data, typically expressed as a standard rate of emissions per unit of activity ($kgCO_{2e}$/unit).

CF denotes the carbon footprint, expressed in metric kilograms of carbon dioxide equivalents ($kgCO_{2e}$) (Valls -val and Bovea, 2022).

Table 2. Net calorific value of fuels

Fuel type	**Natural gas**	**Gasoline**	**Diesel**
Transformation factor (Tj/Gg)	48	44.3	43

Table 3. Emission factors of fuels

Fuel type	**Natural gas**	**Gasoline**	**Diesel**
Emission Factor (kg/Tj)	56100	69300	74100

In the IPCC Tier 1 approach, the CO_2 emission from the university's electricity consumption is calculated by multiplying the consumption amount by the emission factor of 0.478 kilograms per kilowatt-hour (kg/kWh). While calculating the emissions from electricity consumption, the transmission and distribution losses should be considered. The loss and theft percentages arising from the transmission and distribution of electricity were taken as 1.93% and 12.7%, respectively with a total of 14.63% (Alagöz et.al, 2022).

2.4. DEFRA (Department for Environment, Food and Rural Affairs- UK) Methodology

The UK Department for Environment, Food and Rural Affairs (DEFRA) aims to protect, promote and sustain the natural environment. This institution carries out studies in terms of sustainability, especially within the scope of global warming and greenhouse gas emissions. To carry out these studies, it regularly publishes carbon emission coefficients in a wide range of areas such as all emission gasses, transport vehicles, food consumption, and all energy consumption (Alagöz et.al, 2022). The emission coefficients reported by DEFRA in 2023 are given in Table 4.

Table 4. DEFRA Emission Factors (DEFRA, 2023).

	Scope 1			Scope 2	
	Natural Gas	**Gasoline**	**Diesel fuel**	**Electricity**	**Water**
Unit	kg/m^3	kg/L	kg/L	kg/kWh	kg/m^3
Emission Factor	2.04	3.17	2.66	0.21	0.177

3. Results and Discussion

Results of the calculations made by using the IPCC Tier 1 approach and DEFRA conversion factors to determine BEUN's CO_2 emissions for the year 2023 are presented in Table 5 and the contributions of each activity are shown in Figure 3.

In the study, carbon emissions related to water consumption are calculated using the DEFRA methodology, but this calculation is not accounted for by the IPCC. According to the IPCC method, carbon emissions are primarily attributed to electricity consumption, totaling 1456.23 tonnes annually, categorized within scope 2. Following electricity consumption, natural gas consumption contributes 822.51 tonnes, while diesel fuel consumption for vehicles accounts for 59.33 tonnes, and gasoline consumption for vehicles amounts to 23.17 tonnes. Emissions from sources other than electricity consumption fall under scope 2 and are calculated at a total of 905.01 tonnes.

Table 5. BEUN's CO_2 emissions for the year 2023.

Emissions (Ton CO_2)	**Scope 1**				**Scope 2**			**TOTAL**
	Natural Gas	**Gasoline**	**Diesel fuel**	**Total**	**Electric**	**Water**	**Total**	
IPCC	822.51	23.17	59.33	905.01	1456.23		1456.23	2361.24
DEFRA	930.00	32.32	57.97	1020.29	637.1	39.96	677.06	1697.35

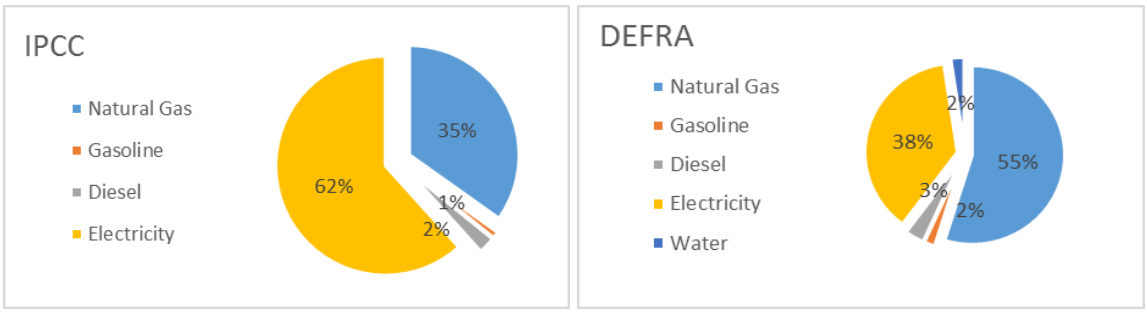

Figure 3. Contribution of different activities to total carbon emissions.

The University of Oulu reported 19,072 tonnes of CO_2 e in 2019, which is considerably higher than the 2,361.24 tonnes of carbon emissions computed in this study. This discrepancy can be explained by variations in the size, operations, and energy use of the institutions (Kiehle et.al, 2023). According to the DEFRA Method it is observed that annual scope 1 CO_2 emissions amount to 930 tonnes from natural gas, 57.97 tonnes from diesel fuels, 32.32 tonnes from gasoline, totaling 1020.29 tonnes. Additionally, within this method, emissions from water consumption in scope 2 were assessed and calculated as 39.96 tonnes. The CO_2 emission resulting from electricity consumption is determined to be 637.1 tonnes, contributing to a total scope 2 emissions of 1697.35 tonnes.

DEFRA's total CO_2e emission results are lower compared to those obtained from the IPCC Tier 1 approach. This variance stems from the generalized nature of the emission factors employed in the IPCC Tier 1 calculations. This discrepancy is specifically highlighted in DEFRA's national data report for England.

The carbon emissions estimated in this study are substantially lower than those found in a study by Özçelik (2017) on the Terzioğlu Campus of Çanakkale Onsekiz Mart University. The carbon footprint of the campus was calculated by Özçelik's study to be 19,706.08 t CO_2e using Approach 1 and 10,122.15 t CO_2e using Approach 2. Natural gas emissions, the university's fleet of vehicles, water and power use, garbage production, and emissions from staff and student mobility were all taken into account in these estimates. On the other hand, energy consumption (natural gas and electricity) is the main contribution to the current study's total of 2,361.24 t CO_2e annually, which does not include transportation emissions (Özçelik, 2017). When compared to the study conducted by Alagöz et al. (2022) on the Central Campus of Elektrik Üretim Anonim Şirketi (EÜAŞ), this research calculates slightly lower total carbon emissions. Based on the actions of 1,126 employees, Alagöz et al. reported a total carbon footprint of 2,570 t CO_2e for 2021, with a per capita emission of 2.28 t CO_2e. Their analysis took into account emissions from natural gas heating, power and

water use, campus vehicle fuel use, service network transportation, staff travel both domestically and abroad, and employee use of private vehicles (Alagöz et. al., 2022).

4. Conclusion

Global climate change, one of the major disasters of the 21st century, has begun to make its impact felt more and more in cities every year with extreme weather events. Carbon emissions from transportation and housing production have led to urban heat island formations and disrupted climatic comfort. In this context, strategies have begun to be developed to reduce CO_2 emissions in urban areas, which are considered to be the areas that will be most affected by climate change.

Nature and the environment are a phenomenon that can renew itself without any artificial influence from the outside. However, due to their greed for consumption, human beings use nature rudely and do not leave a chance to renew themselves. The most important indicator of this reckless use is the carbon footprint. How much damage we cause to nature is related to the size of this footprint.

The research aims to determine the carbon footprint of Zonguldak Bülent Ecevit University by looking at its carbon emission values in 2023. In line with the aforementioned purpose, the research is important in terms of revealing what responsibilities universities, which are one of the places where environmental protection awareness is given, undertake in terms of sustainability and the work done by universities to fulfill these responsibilities.

Therefore, BEUN should prioritize electricity consumption in its fight against greenhouse gas emissions. In this context, both staff and students should be made aware of reducing electricity consumption. Unnecessary energy consumption should be avoided. They are required to use the university's solar energy systems applications to meet the required energy needs. Due to the active use of air conditioning systems within the university, priority should be given to absorption cooling systems that can be used with renewable energy sources. In addition, the number of central VRF systems should be increased instead of split air conditioners used within the University.

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References

Alagöz, İ., Coşkun, E., Babaoğlu, S., Kaykaç, R., & Cidacı, A. (2022). EÜAŞ Merkez Kampüs 2021 Yılı Karbon Ayak İzinin Hesaplanması. *Çevre İklim ve Sürdürülebilirlik*, *23*(2), 161-166.

Awanthi, M.G.G., & Navaratne, C.M. (2018). Carbon footprint of an organization: a tool for monitoring impacts on global warming. *Procedia Eng*., *212*: 729-735, Doi: 10.1016/j.proeng.2018.01.094.

Bajželj, B., Richards, K. S., Allwood, J. M., Smith, P., Dennis, J. S., Curmi, E., & Gilligan, C. A. (2014). Importance of food-demand management for climate mitigation. *Nature Climate Change, 4(*10), 924-929.

Binboğa, G., & Aylin, Ü. N. A. L. (2018). Sürdürülebilirlik Ekseninde Manisa Celal Bayar Üniversitesi'nin Karbon Ayak İzinin Hesaplanmasına Yönelik Bir Araştırma. *Uluslararası İktisadi ve İdari İncelemeler Dergisi*, *21*, 187-202.

Çerçi, M. (2021). 'IPCC TIER 1 ve Defra Metodları İle Karbon Ayak İzinin Belirlenmesi: Erzincan Binali Yıldırım Üniversitesi Örneği' Yüksek Lisans Tezi, Erzincan Binali Yıldırım Üniversitesi, Fen Bilimleri Enstitüsü, Erzincan.

da Silva, L. A., Dutra, A. R. D. A., Soares, T. C., Birch, R. S., & Guerra, J. B. S. O. D. A. (2023). Trends in research: carbon footprint reduction in universities as a way to achieve a green campus. *International Journal of Sustainability in Higher Education*, *24*(3), 584-601.

DEFRA, (2023), Greenhouse gas reporting: conversion factors 2023, https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023 (Erişim tarihi: 20.01.2023).

Gao, T., Q. Liu, & J. Wang. (2014). A comparative study of carbon footprint and assessment standards.*International Journal of Low-Carbon Technologies 9(3)*, 237–243. http://ijlct. oxfordjournals.org/content/9/3/237.abstract.

IPCC, Intergovernmental Panel on Climate Change (Simon Eggleston, Leandro Buendia, Kyoko Miwa, Todd Ngara & Kiyoto Tanebe). (2006). *IPCC Guidelines for National Greenhouse Gas Inventories*. The National Greenhouse Gas Inventories Programme.

IPCC, Intergovernmental Panel on Climate Change (Martin Parry, Osvaldo Canziani, Jean Palutikof, Paul van der Linden & Clair Hanson). (2007). *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Intergovernmental Panel on Climate Change.

IPCC, Intergovernmental Panel on Climate Change (Christopher B.Field, Vicente R. Barros, David Jon Dokken, Katharine J.Mach, Michael D. Mastrandrea, T. Eren Bilir , Monalisa Chatterjee, Kristie L. Ebi, Yuka Otsuki Estrada, Robert C. Genova, Betelhem Girma, Eric S. Kissel, Andrew N. Levy, Sandy MacCracken, Patricia R. Mastrandrea & Leslie L. White). (2014). *Climate Change 2014 Impacts, Adaptation, and Vulnerability Part A: Global and Sectoral Aspects*. Intergovernmental Panel on Climate Change.

Kiehle, J., Kopsakangas-Savolainen, M., Hilli, M. &Pongrácz, E. (2023). Carbon footprint at institutions of higher education: The case of the University of Oulu, *Journal of Environmental Management, 329*, 117056, ISSN 0301-4797, Doi: https://doi.org/10.1016/j.jenvman.2022.117056.

Özçelik, G. (2017). 'Çanakkale Onsekiz Mart Üniversitesi Terzioğlu Kampüsünün enerji ve karbon ayak izi açısından değerlendirilmesi' Yüksek Lisans Tez, Çanakkale Onsekizmart Üniversitesi, Fen Bilimleri Enstitüsü, Çanakkale.

Robinson, O.J., Tewkesbury, A., Kemp, S., & Williams, I.D. (2018). Towards a universal carbon footprint standard: a case study of carbon management at universities. *Journal of Cleaner Production*, *172*, 4435-4455, Doi: 10.1016/j.jclepro.2017.02.147.

Valls-Val, K., & Bovea, M. D. (2022). Carbon footprint assessment tool for universities: CO2UNV. *Sustainable Production and Consumption, 29*, 791-804.

Varón -Hoyos, M., Osorio-Tejada, J., & Morales-Pinzón, T. (2021). Carbon footprint of a university campus from Colombia. *Carbon Management*, *12*(1), 93-107.

Ward, J. D., Sutton, P. C., Werner, A. D., Costanza, R., Mohr, S. H., & Simmons, C. T. (2016). Is decoupling GDP growth from environmental impact possible?. *PloS one, 11*(10), e0164733.

WRI, (2004). The greenhouse gas protocol, World Resources Institute; World Business Council for Sustainable Development, Geneva, Switzerland; Washington, DC.

Yañez, P., Sinha, A., & Vásquez, M. (2019). Carbon footprint estimation in a university campus: Evaluation and insights. *Sustainability*, *12*(1), 181.