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Efficient Web-Based Application Development for Carbon Footprint Calculation: Example of Burdur Province

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Abstract

With each passing year, people's consumption activities create permanent effects on nature. In this context, the carbon footprint has been determined as a way of expressing the magnitude of this impact. In addition, the carbon footprint is defined as a measure of the damage caused by human activities to the environment in terms of the amount of greenhouse gases produced and measured in units of carbon dioxide. In this study, an easy-to-use and effective carbon footprint calculation engine has been created for carbon footprint calculation. Also, this application has been designed and developed as a web-based application – http://karbon-ayakizi.com/ (this site has been in active use between January 2020 and January 2021, but it is currently inactive). Furthermore, a real case study on the carbon footprint of an education institution located in the city centre of Burdur has been conducted, and so the accuracy and functionality of the developed application has been showed and demonstrated. For this purpose, natural gas consumption within Scope-1, electricity consumption within Scope-2, private personal cars, public transportation service vehicles and water consumption data within Scope-3 have been considered in carbon footprint measurement. In the light of these obtained numerical data, the efficiency and the reliability of the developed carbon footprint calculation engine – application – with its trustworthy results have been explained and showed in detail.

Keywords: Carbon footprint, calculation engine, web-based application, environmental pollution

1. Introduction

The ecological balance (environmental balance) is defined as the system that consists of the physical and biological elements of the natural environment and in which the mutual interactions between living and non-living things continue in a way that preserves the general character of the ecosystem [1]. One of the biggest factors in the deterioration of the ecological balance is defined as the traces left in nature because of some activities carried out by humanity while continuing its life, depending on various effects and factors such as the rapid increase in population, industrial and technology activities, global competition, consumption needs, unconscious and unlimited consumption understanding and mentality [2-4]. As a result of these traces, various problems on a global scale such as pollution of the natural environment, depletion of natural resources, global climate change, and increase in barren areas and the threat of extinction by decreasing some species arise. In this context, climate change, which is the most obvious environmental problem, is caused by greenhouse gas emissions that reach the atmosphere because of human activities [5,6].

In recent years, many models, methods and indicators have been put forward in the quantitative calculation of the sustainability of societies and individuals. The "ecological footprint", developed to measure the impact of individuals on natural ecosystems and their sustainability levels, is one of these indicator tools [2,7,8]. Depending on human consumption activities, the ecological footprint components are expressed in six basic areas in *Figure 1* as grassland footprint, forest area footprint, fishery area footprint, agricultural land footprint, built area footprint, and carbon footprint [9]. In addition, ecological footprint is defined as the fertile land and water area, biologically expressed in "global hectares" (gha), required to produce the resources consumed by an individual, community, institution, organization or activity and to remove the waste it generates, with current technology and resource management [9].

Figure 1. Ecological footprint components [9].

2. Carbon Footprint

The largest component of the ecological footprint is the carbon footprint [10]. As it is the largest component of the total footprint on a global scale, the carbon footprint constitutes the largest component of Turkey's total ecological footprint – 46% (1.24-1.36 gha per capita) [9] as shown in *Figure 2*. In addition, carbon footprint includes emissions from fossil fuels used in the country, emissions from the production process of products purchased from abroad, the country's share in international trade emissions and non-fossil fuel carbon emissions [9].

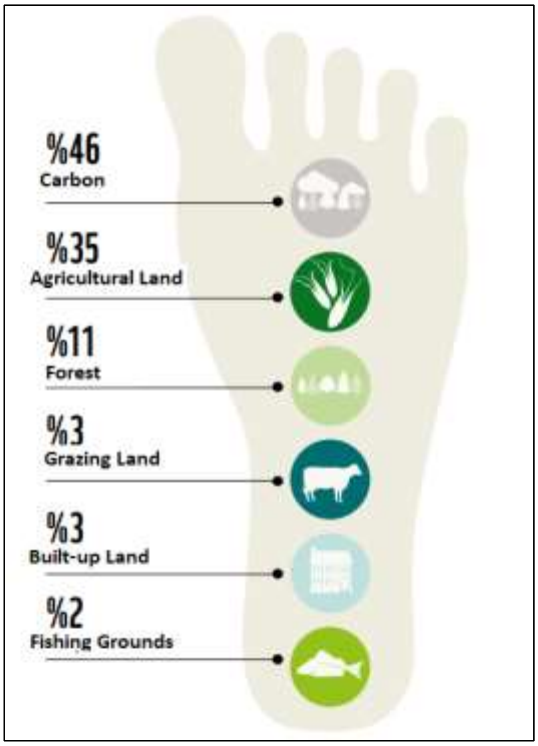

Figure 2. Turkey's ecological footprint components [9].

"People" as defined by the "Kyoto Protocol" [6] in *Figure 3*: leave a trace in nature as a result of the activities they carry out in transportation, heating, shelter, products, services and many other subjects [11]. Moreover, carbon footprint calculations are made in order to provide mandatory or voluntary greenhouse gas commitments of companies, institutions and organizations, to determine their effects on climate change and to participate in emission trading mechanisms.

Figure 3. Carbon footprint [11].

In this way, in *Table 1* [6] in the following, the greenhouse gases determined within the "Kyoto Protocol" have been shown and explained.

Table 1. Greenhouse gases by Kyoto Protocol [6].

Symbol	Given name	CO_2	Main sources
CO_2	Carbon dioxide	1	Combustion of Fossil Fuels, Forest Fires, Cement Production
CH_4	Methane	21	Landfills, Production and Distribution of Oil and Natural Gas, Digestion of Farm Animals Fermentation in Systems
N_2O	Nitrous oxide	310	Combustion of Fossil Fuels, Fertilizers, Nylon Production
HFC_S	Hydrofluorocarbons	140-11700	Refrigerator Gases, Aluminum Melting, Semi Conductor Production
PFC_S	Perfluorocarbons	6500-9200	Aluminum Production, Semiconductor Production
SF_6	Sulfur Hexafluoride	23900	Electricity Transmission and Distribution Systems, Magnesium production

The carbon footprint, which can be formed personally and institutionally as a result of people's activities, may be calculated by grouping them in two [12] or three scopes [13-17]. In this context, Scope-1 includes activities that directly create carbon footprints. In this category, there are fossil fuels used by institutions and organizations for heating or energy needs and emissions created by the fuels of the vehicles within the organization. Also, Scope-2 indirect carbon footprint includes emissions due to steam, cooling or hot water purchased by the institution from another institution or organization, and emissions caused by the electrical energy consumed by the institution. Moreover, Scope-3 is another indirect carbon footprint is the most difficult and troublesome to calculate, which does not have direct emissions from the institution or organization but originates from the activities of the institution. In this way, activities such as outsourced transportation services, emissions from the wastes of the institution or organization, and catering services taken from outside are included in this scope [18]. According to the data of the Wildlife Conservation Foundation [9], the footprint per capita in Turkey is 2.7 (gha). This figure is much more than the world average [19].

In the literature reviews on carbon footprint, which is an important concept in the preservation of ecological balance, studies on this subject in Turkey are more limited than studies conducted abroad, and various studies have been carried out in universities as educational institutions [6, 20-23] and there is no study on this subject in other educational institutions [11]. Furthermore, studies on the subject emphasize the need for the development of education, program and teaching materials and various subject-based applications for reducing carbon footprint values in terms of individual, social and institutional aspects [2].

3. Method

The universe of the study consists of education and training institutions in the city centre of Burdur. In this context, the sample of the research is one of the education and training institutions in the city centre of Burdur, using the convenient/accidental sampling method, considering that the sample is easily accessible and practical due to the limitations in terms of time, money and labour [24]. In *Figure 5*, the general boundaries of the educational institution, which has been considered as a sample, have been indicated visually. Also, the study has been done and carried out by applying the following steps in *Figure 4*.

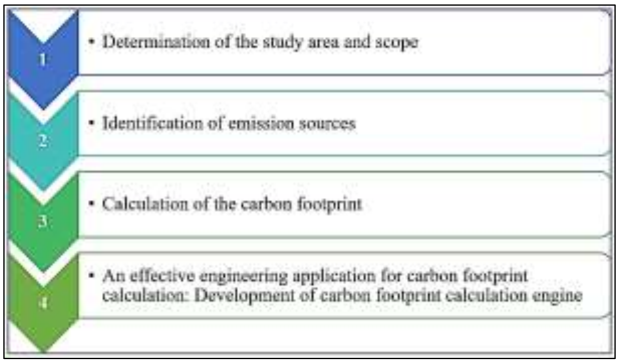

Figure 4. Steps for calculating carbon footprint.

Figure 5. The general boundaries of the education institution in Burdur [25].

The study, whose general boundaries have been indicated in *Figure 5*, located in the centre of Burdur, has been carried out. As of 2019-2020 academic year, there have been 27 school staff – 21 staff members, 2 administrators, 1 civil servant, 2 service personnel and 1 security – 244 students – primary, secondary, high school – in total. In addition, the distance of the institution to the city centre of Burdur is approximately 4.5 kilometres.

Emissions arising from the activities carried out directly or indirectly by the educational institution in the study are listed in the following:
Scope-1: Various sources that directly emit greenhouse gas emissions from the organization itself.
Scope-2: Emissions to the atmosphere associated with indirect consumption of energy such as purchased electricity, heat, steam and cooling.
Scope-3: Emissions arising from the activities of the organization but not under the control of the organization and caused by various sources that cannot be classified as Scope-2 emissions.

Within the framework of the scopes explained above, the emissions created by the natural gas consumption of the institution for fuel within Scope-1; electricity consumption for electrical energy within Scope-2; emissions arising from the transportation of students and employees (teachers, civil servants, servants, security guards, etc.) and water consumption are evaluated within Scope-3. However, it is not included in the carbon footprint measurement due to the lack of food service and consumption and the lack of data on chemicals/consumables purchased.

Scope-1, natural gas used for heating; Scope-2, electricity consumption; and Scope-3, it possible to calculate the data on water consumption annually and in order to provide more realistic information, the data of 2019 have been included in the scope of the study. In addition, the data of the institution regarding the emission sources included in the scope of the examination and research have been obtained from the institution administration on the basis of the relevant invoices. Moreover, private personal cars used for the transportation of students and employees (teachers, civil servants, servants, security guards, etc.), and service vehicles in public transportation considered within Scope-3, have been determined and the emissions caused by these have been found out, revealed and calculated in detail.

4. Carbon Footprint Calculation Engine

In order to apply the carbon footprint calculation engine, the work-flow diagram has been determined and the study has been revealed and carried out in this way. Within the framework of this schedule – in *Figure 6* –, the application has been planned, designed, developed, necessary tests have been carried out, the writing has been completed and then implemented into the life.

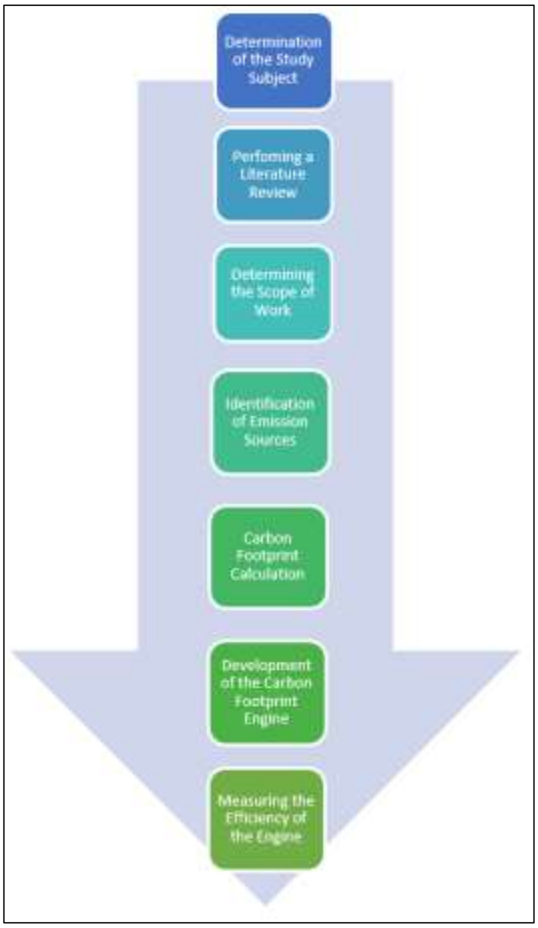

Figure 6. The schedule in work-flow diagram.

Scientific formulas for calculating and finding carbon emission values [11,26] have been explained in the following, and a carbon footprint calculation engine – application – has been designed and developed in the line with these specific formulas (formula 1 to 9).

EtCO_2/year (natural gas) **[11]** **(1)**
= (((Natural gas usage (m^3) * 0.67) * 0.001) * (56100 * 0.001) * 48 * 1) * 0.001
0,67=Average Density; 0,001=kg-ton; 56100=Emission Factor; 0.001=kg-ton; 48=Oxidation Factor; 1=Oxidation Factor; 0,001=ton-Gg

EtCO_2/year (electricity) **[11]** **(2)**
= ((Electricity consumption (kWh) * 0.4603 * 0.133) + (Electricity consumption (kWh) * 0.4603)) * 0.001
0.4603=Emission Factor; 0.133=Loss Factor;
0.4603= Emission Factor; 0.001=10^{-3}

EtCO_2/year (gasoline (liter)) **[11]** **(3)**
= (((Gasoline usage (liter) * 0.735) * 0.001) * (69300 * 0.001) * 44.3 * 1) * 0,001

***EtCO_2/year (gasoline (km)*)) [11]** **(4)**
= ((((kilometer/100) * 7.5 * 0.735) * 0.001) * (69300 * 0.001) * 44.3 * 1) * 0.001
0.735= Average Density; 0.001=kg-ton; 69300= Emission Factor; 0.001=kg-ton; 44.3= Oxidation Factor; 1= Oxidation Factor; 0.001=ton-Gg

EtCO_2/year (diesel (liter)) **[11]** **(5)**
= (((Diesel use (liter) * 0.83) * 0.001) * (74100 * 0.001) * 43 * 1) * 0.001

EtCO_2/year (diesel (km)) **[11]** **(6)**
= ((((kilometer/100) * 7.5 * 0.83) * 0.001) * (74100 * 0.001) * 43 * 1) * 0.001
0.83= Average Density; 0,001=kg-ton;
74100= Emission Factor; 0,001=kg-ton; 43= Oxidation Factor; 1= Oxidation Factor; 0,001=ton-Gg

EtCO_2/year (water) **[11]** **(7)**
= (Water consumption (m^3)) * 0.0014
0.0014= Emission Factor

EtCO_2/year (public transportation) **[11]** **(8)**
= (((((Kilometer * 0.13)/number of people) * 0.830 * 0.001) * (74100 * 0.001) * 43 * 1) * 0,001) * number of people
0.13=Diesel use; 0.830= Average Density; 0.001=kg-ton; 74100= Emission Factor; 0.001=kg-ton;
43= Oxidation Factor; 1= Oxidation Factor;
0,001=ton-Gg

Number of Trees to be Planted Against Carbon Emission **[27]** **(9)**
= Total Carbon Footprint (Ton) / (((24 * 2.3) * 365) * 0.001)

While developing the carbon footprint calculation engine, Visual Studio Code platform (IDE) has been used in the web-based application. Also, PHP, HTML, CSS and JavaScript languages have been used through this platform. In addition, the main part of the site has been written in PHP, and CSS has been used for the design part. Moreover, functions for carbon footprint calculation formulas have been developed with the JavaScript language. Furthermore, HTML has been used for the basic texts on the site. In addition, in order to prevent errors in user input, relevant commands have been written so that character entries and number entries with minus (–) values that should not be in formulas have not been accepted. Before the designed and

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developed site has been opened to internet access, necessary trials and tests have been carried out and applied in the local environment via the AppServ server. As a result of the successfully completed tests, the necessary domain (domain name) and hosting (domain service) transactions have been made and the engine link address http://karbon-ayakizi.com/ (this site has been in active use between January 2020 and January 2021, but it is currently inactive) has been opened to internet access. Also, the interface for obtaining the necessary data from the user on the developed site has been showed in *Figure 7*; the interface for writing the outputs to the screen has been given in *Figure 8*; the interface for calculating the tree to be planted depending on the outputs has been showed in *Figure 9*. In addition, in *Figure 10* in the following, the source code fragment of the index of the developed site has been given in detail.

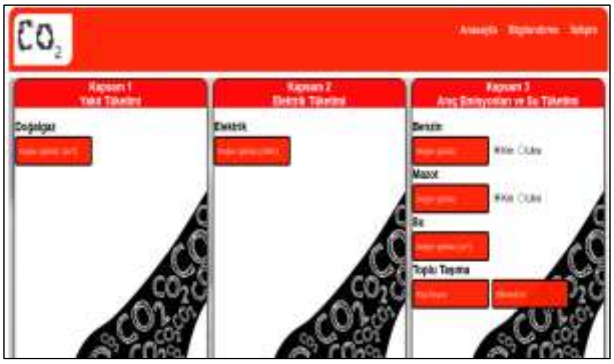

Figure 7. Interface for inputs in the site.

Figure 8. Interface for outputs via calculate button.

Figure 9. Interface for tree calculation via see button.

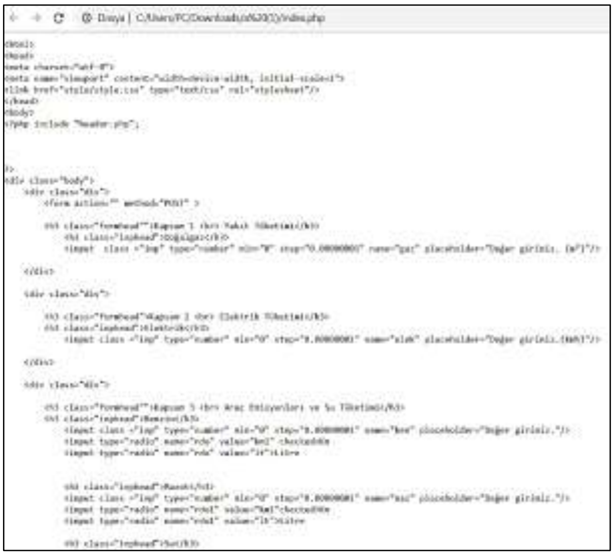

Figure 10. Source code fragment of the site index.

5. Important Findings Regarding the Carbon Footprint Calculation Engine

In the study carried out in the 2019-2020 academic year, based on the 2018-2019 academic year, it has been stated that the natural gas consumption within Scope-1 has been approximately annually 38,000 m^3 (as a result of the findings obtained from the monthly natural gas bills) in the light of the findings summarized in *Table 2* below, and it has been concluded that this consumption caused 69 tons of carbon emissions. In addition, when the electricity consumption in the Scope-2 calculation has been examined, it has been determined that the annual average is 19.000 kWh (as a result of the amounts obtained from the monthly electricity bills), and it has been stated that this electricity consumption causes around 10 tons of carbon emissions. Furthermore, when the annual use of gasoline and diesel products within Scope-3 has been examined, it has been calculated that these have been approximately 12,500 liters (~169,000 km, 30 gasoline cars in total) and 14,000 liters (~187,000 km, 28 diesel cars in total), respectively. It has been revealed that a total of 68 tons of carbon emissions have been exposed to the environment. Moreover, it has been stated that the annual water consumption and usage, which has been also included in Scope-3, has been approximately 1,600 m^3 (in the light of the usage calculations obtained from the monthly water bills), and it has been calculated that it has caused around 2 tons of carbon emissions. When looked at the last parameter in Scope-3, which has been public transportation, it has been calculated that the vehicles serving the school travel an average of 200,000 km (23 diesel-powered public transportation vehicles for 20 people) annually and has caused approximately 69 tons of carbon emissions. In the light of the data that emerged, it has been concluded that the education institution within the province of Burdur has caused a total of about 216 tons of carbon emissions in the 2019-

2020 academic year - based on the 2018-2019 academic year – in Scope-1, Scope-2 and Scope-3 frameworks. Also, it has been calculated that approximately 11 trees (based on the rates specified in the TEMA foundation [27]) have been needed to control this emission and capture carbon. In this context, the carbon emission findings obtained as a result of the calculations have been summarized in *Table* 2 in the following.

Table 2. Total carbon emission of the education institution in Burdur province.

Annually	Scope-1	Scope-2	Scope-3				Total
	Natural gas	Electricity	Gasoline	Diesel	Water	Public Transport	Total Carbon Footprint
Consumption/Use	38272 m^3	19173.48 kWh	12672 L	13962 L	1586 m^3	200834.4 km	215.83 ton EtCO_2/year
Output	69.05 ton	9.99 ton	28.59 ton	36.92 ton	2.22 ton	68.06 ton	
Total	69.05 ton	9.99 ton	136.78 ton				215.83 ton EtCO_2/year

6. Conclusion and Discussion

In the study, a web-based carbon footprint calculation engine has been designed and developed. In addition, the carbon footprint of an education institution located in the city centre of Burdur has been calculated as a real case study. In the light of the calculations made and the results obtained, the annual carbon emission of the education institution in Burdur province due to the fuel (natural gas) used for heating the institution in Scope-1 has been 69.05 tons; in Scope-2 the annual carbon emission due to electricity consumption has been 9.99 tons; in Scope-3, annual carbon emission based on vehicle emissions (gasoline and diesel) and water consumption has been 136.78 tons. Finally, the annual total carbon emission value of the institution has been 215.83 tons. In this context, it has been determined that at least 11 adult trees have to be located within the general boundaries of the institution for the absorption of this carbon value, according to the equation and the formula set by TEMA Foundation [27].

In addition to these, the study has provided both the calculation of the carbon footprint (individual and institutional) and the demonstration of how the damage to the environment could be improved – especially with tree planting. In this respect, a face-to-face meeting was held with the Burdur Forestry Operations Directorate within the scope of the study regarding the reduction of carbon emissions by planting trees and it was promised that planting could be done in each year in the areas included in the afforestation program. Also, some discussions on climate change were held at the World Economic Forum held in Davos, Switzerland on January 24, 2020, and it was set to goal of growing 1 trillion trees [28]. In this context, it has been clearly observed that the conducted research and the presented work have been valid and meaningful both in national and international framework. Within the scope of the study, the site http://karbon-ayakizi.com/ (this site has been in active use between January 2020 and January 2021, but it is currently inactive) has been designed and developed, and its effectiveness and trustworthy results have been showed with a specific case study.

7. Future Works

The designed and developed website http://karbon-ayakizi.com/ has been extracted, created and emerged within the framework of case analysis based on the parameters that have been included in Scope-1, Scope-2 and Scope-3 that may cause carbon emissions within the framework of the carbon footprint of the education institution in Burdur province. In addition, it has been aimed to get a general domain name related to the site, and to enable people to reach it quickly and comfortably on the internet, and it has been also aimed to move forward in a forward-looking, cumulative and collective way that has been open to development and improvement. With the addition of all the parameters used in the carbon footprint calculation of this study, which emerged with a case analysis, in the light of the scientific formulas in the academic world, all users (individuals, institutions, organizations, companies, foundations, etc.) will calculate their own carbon footprints and as a result, it will be that people become more conscious (environmental, social, societal, etc.) related tree calculation, nature and environment. In addition to this goal, it will be able to create a large data set in the light of the information to be obtained. Moreover, various purposes related to the data set to be obtained with the help of artificial intelligence, machine learning and deep learning algorithms and methods, which are developed on the basis of mathematics, and which are very popular in the informatics world these days and will not lose their importance for many years. With the contribution of these techniques, operations such as classification, clustering, advice, prediction and ordering will be applied and carried out in this carbon footprint study in the future. In this context, the study will be able to calculate the carbon footprint (private & general), specify the required tree planting, and present a purposeful and detailed report in the light of the available data and information.

Acknowledgement

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Author’s Contributions

Mustafa Batar: Did all the work in the study (did literature review, created calculation engine, designed and developed application, did analysis and case study, did paper formatting, etc.)

Ethics

Author declares that there are no ethical issues related to publication of this manuscript. The performed study is out of scope of any ethical issues.

References

[1]. Çepel, N. 1992. Elmalı sedir ormanlarının ekolojik önemi. *İstanbul Üniversitesi Orman Fakültesi Dergisi;* 42: 1-8.

[2]. Ertekin, P. 2012. *Sürdürülebilir kaynak kullanımına yönelik çevre eğitimi uygulamalarının ilköğretim öğrencilerinin karbon ayak izi konusunda bilinçlenmeleri üzerine etkisi.* Yüksek Lisans Tezi, Muğla Sıtkı Koçman Üniversitesi Eğitim Bilimleri Enstitüsü, Muğla.

[3]. Özer, B. 2012. *Türkiye elektrik sektöründe CO2 emisyonu azaltma potansiyeli üzerine senaryo analizleri.* Doktora Tezi, İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

[4]. Özsoy, C. E. 2015. Düşük karbon ekonomisi ve Türkiye'nin karbon ayak izi. *HAK-İŞ Uluslararası Emek ve Toplum Dergisi* 4: 198-215.

[5]. Rana R., Ingrao C., Lombardi M., Tricase C. 2016. Greenhouse gas emissions of an agro-biogas energy system: Estimation under the renewable energy directive. *Science of The Total Environment;* 550:1182-1195.

[6]. Özçelik, G. (2017). *Çanakkale Onsekiz Mart Üniversitesi Terzioğlu Kampüsü'nün enerji ve karbon ayak izi açısından değerlendirilmesi.* Yüksek Lisans Tezi, Çanakkale Onsekiz Mart Üniversitesi, Çanakkale.

[7]. Jia, J., Zhao, J., Deng, H., Duan, J. 2010. Ecological footprint simulation and prediction by ARIMA model-A case study in Henan Province of China. *Ecological Indicators;* 10: 538-544.

[8]. Lei, K., Hu, D., Wang, Z., Yu, Y., Zhao, Y. 2009. An analysis of ecological footprint trade and sustainable carrying capacity of the population in Macao. *The International Journal of Sustainable Development and World Ecology;* 16: 127-136.

[9]. WWF, 2012. Türkiye'nin Ekolojik Ayak İzi Raporu. https://www.footprintnetwork.org/content/images/article_uploads/Turkey_Ecological_Footprint_Report_Turkish.pdf (accessed at 31.07.2021).

[10]. Borucke, M., Moore, D., Cranston, G., Gracey, K., Iha, K., Larson, J., Lazarus, E., Morales, J. C., Wackernagel, M., Galli, A. 2013. Accounting for demand and supply of the biosphere's regenerative capacity: The National Footprint Accounts' underlying methodology and framework. *Ecological Indicators;* 24: 518-533.

[11]. Üreden, A. 2019. *Sürdürülebilir yaşam için karbon ayak izi (Çankırı Karatekin Üniversitesi örneği).* Yüksek Lisans Tezi, Çankırı Karatekin Üniversitesi Fen Bilimleri Enstitüsü, Çankırı.

[12]. Jones, C. M., Kammen D. M. 2011. Quantifying carbon footprint reduction opportunities for U.S. households and communities. *Environmental Science and Technology;* 45: 4088-4095.

[13]. Adanalı, K. Carbon management and model applications. 7th International Ankiros Foundry Congress, İstanbul, Turkey, 2014.

[14]. Bekiroğlu, O. Sürdürülebilir kalkınmanın yeni kuralı: Karbon ayak izi. II. Elektrik Tesisat Ulusal Kongresi, İzmir, Türkiye, 2011.

[15]. Kitzes J., Peller A., Goldfinger S., Wackernagel M., 2007. Current methods for calculating national ecological footprints accounts. *Science for Environment and Sustainable Society;* 4: 1-9.

[16]. Mutlu, V., Özgür, C., Kaplan Ş. 2018. Determination of carbon footprint in rubber ındustry. *Bilge International Journal of Science and Technology Research;* 2: 139-146.

[17]. Üreden, A., Özden, S. 2018. Kurumsal karbon ayak izi nasıl hesaplanır: teorik bir çalışma. *Anadolu Orman Araştırmaları Dergisi*; 4: 98-108.

[18]. Turanlı, A. M. 2015. *Estimation of carbon footprint: A case study for Middle East Technical University.* MSc thesis, Middle East Technical University Graduate School of Natural And Applied Sciences, Ankara.

[19]. WWF, Ekolojik ayak izi. https://www.wwf.org.tr/basin_bultenleri/raporlar/yaayan_gezegen_raporu/yasayangezegenraporu2014/ekolojikayakizi/ (accessed at 31.07.2021).

[20]. Başoğul, Y. 2019. Determining the ecologic and carbon footprints of Adiyaman University faculty of engineering students. *The International Journal of Engineering and Science;* 8: 46-52.

[21]. Eren, Ö., Parlakay, O., Hilal, M., Bozhüyük, B. 2017. Ziraat Fakültesi akademisyenlerinin ekolojik ayak izinin belirlenmesi: Mustafa Kemal Üniversitesi örneği. *Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi;* 34: 138-145.

[22]. Keleş, Ö. 2007. *Sürdürülebilir yaşama yönelik çevre eğitimi aracı olarak ekolojik ayak izinin uygulanması ve değerlendirilmesi.* Doktora Tezi, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

[23]. Yaka, İ. F., Koçer, A., Güngör, A. 2015. Akdeniz University health services vocational determination of carbon footprint. *Electronic Journal of Machine Technologies;* 12: 37-45.

[24]. Büyüköztürk, Ş., Çakmak, E., Akgün, Ö. E, Karadeniz, Ş., Demirel, F. 2018. *Eğitimde Bilimsel Araştırma Yöntemleri*. Ankara: Pegem Akademi.

[25]. Google Maps, Burdur. https://www.google.com/maps/place/Burdur,+Burdur+Merkez%2FBurdur/@37.7325713,30.2474,13z/data=!3m1!4b1!4m5!3m4!1s0x14c42c1038052bdd:0x7f33fbee17399f8b!8m2!3d37.718336!4d30.282333 (accessed at 20.02.2020).

[26]. IPCC, Guidelines for National Greenhouse Gas Inventories. https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html (accessed at 31.07.2021).

[27]. TEMA, TEMA diyor ki; ağaç dikin, küresel ısınmaya el koyun. https://www.tema.org.tr/basin-odasi/basin-bultenleri/tema-diyor-ki-agac-dikin-kuresel-isinmaya-el-koyun (accessed at 31.07.2021).

[28]. INDEPENDENT Türkçe, Davos 2020 sona erdi: İklim değişikliğinin nasıl ele alınacağına dair kafa karışıklığı sürüyor. https://www.indyturk.com/node/122876/d%C3%BCnya/davos-2020-sona-erdi-iklim-de%C4%9Fi%C5%9Fikli%C4%9Finin-nas%C4%B1l-ele-al%C4%B1naca%C4%9F%C4%B1na-dair-kafa (accessed at 31.07.2021).