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INTERACTIVE WEB-BASED CARBON FOOTPRINT CALCULATOR FOR EDUCATIONAL AND AWARENESS PURPOSES

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ABSTRACT

This study presents the development of an interactive web-based simulation designed to help individuals increase their environmental awareness by calculating their annual carbon footprint. The application is built entirely with client-side HTML, CSS, and JavaScript components, requiring no server connection or data sharing. The user can provide parameters such as electricity consumption, type and distance of transportation, heating fuel, flight frequency, diet profile, and waste recycling rate as inputs. The model calculates the total carbon footprint in tCO2e/year by multiplying the annual emissions derived from these inputs by typical emission factors. The calculated results are presented separately for six main categories (Electricity, Transportation, Heating, Flights, Diet, and Waste) and visualized using a dynamic bar chart with the HTML5 Canvas API. Furthermore, the user can observe the effect of changes in the energy mix on total emissions in real-time by switching between the TR Grid, EU Average, and Low Carbon scenarios. The application's strengths include its browser-based architecture, which protects data privacy; real-time calculation; and a customizable modeling approach enabled by its parametric structure. However, emission factors based on national averages and simplified diet/waste models mean the results are approximate in nature. In conclusion, the developed simulation serves not only as a calculation tool but also as an educational instrument that contributes to developing behavioral awareness by visualizing users' lifestyle-related emissions. It is assessed that such open-source digital tools can be effective supportive elements in achieving carbon neutrality goals at both the individual and institutional levels.

Keywords: Carbon Footprint, Emission Factors, Environmental Awareness.

EĞİTİM VE FARKINDALIK AMAÇLI ETKİLEŞİMLİ WEB TABANLI KARBON AYAK İZİ HESAPLAYICISI

ÖZ

Bu çalışma, bireylerin yıllık karbon ayak izlerini hesaplayarak çevresel farkındalıklarını artırmalarına yardımcı olmak amacıyla tasarlanmış etkileşimli, web tabanlı bir simülasyonun geliştirilmesini sunmaktadır. Uygulama, tamamen istemci tarafında (client-side) çalışan HTML, CSS ve JavaScript bileşenleriyle oluşturulmuş olup, herhangi bir sunucu bağlantısı veya veri paylaşımı gerektirmemektedir. Kullanıcı, elektrik tüketimi, ulaşım türü ve mesafeleri, ısınma yakıtı, uçuş sıklığı, beslenme profili ve atık geri dönüşüm oranı gibi parametreleri girdi olarak sağlayabilmektedir. Model, bu girdilerden elde edilen yıllık emisyonları tipik emisyon faktörleri ile çarparak tCO_{2e}/yıl cinsinden toplam karbon ayak izini hesaplamaktadır. Hesaplanan sonuçlar, altı ana kategori (Elektrik, Ulaşım, Isınma, Uçuşlar, Beslenme ve Atık) için ayrı ayrı sunulmakta ve HTML5 Canvas API kullanılarak dinamik bir çubuk grafik ile görselleştirilmektedir. Ayrıca kullanıcı, "TR Şebeke", "AB Ortalaması"

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ve "Düşük Karbon" senaryoları arasında geçiş yaparak enerji karışımındaki değişimlerin toplam emisyon üzerindeki etkisini gerçek zamanlı gözlemleyebilmektedir. Uygulamanın güçlü yönleri arasında, veri gizliliğini koruyan tarayıcı tabanlı mimarisi, gerçek zamanlı hesaplama ve parametrik yapı sayesinde özelleştirilebilir modelleme yaklaşımı yer almaktadır. Ancak, ulusal ortalamalara dayalı emisyon faktörleri ve basitleştirilmiş beslenme/atık modelleri, sonuçların yaklaşık karakterde olmasına neden olmaktadır. Sonuç olarak, geliştirilen simülasyon yalnızca bir hesaplama aracı değil, aynı zamanda kullanıcıların yaşam tarzı kaynaklı emisyonlarını görselleştirerek davranışsal farkındalık geliştirmelerine katkı sağlayan eğitimsel bir araç işlevi görmektedir. Bu tür açık kaynaklı dijital araçların, bireysel ve kurumsal düzeyde karbon nötr hedeflerine ulaşmada etkili birer destekleyici unsur olabileceği değerlendirilmektedir.

Anahtar kelimeler: Karbon Ayak İzi, Emisyon Faktörleri, Çevresel Farkındalık.

1. Introduction

Global climate change poses a critical environmental challenge to humanity in the 21st century. The rapid increase in the use of fossil fuels following the Industrial Revolution, combined with energy consumption, transportation, industrial, and agricultural activities, has significantly elevated the concentration of greenhouse gases (especially carbon dioxide, methane, and nitrous oxide) in the atmosphere. This increase has led to a global average temperature rise of approximately 1.2 °C over the last century, disrupting the climate system's equilibrium. Rising temperatures increase the frequency of extreme weather events, sea-level rise, and ecosystem destruction [1-3].

At the root of this global problem lies the carbon footprint left by the daily activities of every individual and institution. The carbon footprint is the measure of the total greenhouse gas emissions, expressed in carbon dioxide equivalent (tCO_{2e}), directly or indirectly caused by a person, community, or product. Consequently, individual lifestyles particularly electricity consumption, transportation choices, dietary habits, and waste management, account for a significant portion of total emissions [4].

In recent years, global climate policies have focused on increasing individual awareness. International frameworks such as the European Union's Green Deal, the United Nations Sustainable Development Goals (specifically Goal 13: Climate Action), and the Paris Agreement aim to engage not only states and corporations but also individuals in climate action. In this context, carbon footprint calculators have become a vital tool for transformation [5-7].

Carbon footprint calculators quantify individuals' energy and consumption habits, making the environmental impacts of their lifestyles visible. By entering information such as electricity consumption, modes of transport, flight frequency, or dietary choices, users can view their annual carbon emissions. This visibility facilitates behavior change: steps such as switching to energy-efficient appliances, preferring public transportation, adopting a plant-based diet, or sorting waste more effectively can yield tangible reductions in personal emissions [8-10].

However, many existing online tools provide only superficial estimates and do not permit customization of emission factors. This makes accurate assessment difficult for users across different energy systems (e.g., the Turkish and European electricity grids) or lifestyles. Building on this gap, the developed Carbon Footprint – Detailed Calculator aims to address this deficiency by providing users with an interactive interface and a parametric model [11-15].

The tool calculates the carbon footprint across six main components: electricity, transportation, heating, flights, diet, and waste. The user can manually adjust the emission factors and energy-efficiency coefficients, thereby testing different scenarios (e.g., what happens if the share of renewable energy increases?). The calculation results are visualized through dynamically updated charts, enabling easy monitoring of each category's share of the total.

The objective of this study is to examine the design principles, mathematical model, and potential contribution to environmental awareness of this web-based calculator. The developed tool is not only a technical calculation system but also an educational instrument designed to foster climate consciousness.

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Therefore, this work seeks to offer a digital contribution to both the field of environmental informatics and sustainable living practices

2. Methodology

2.1. System Architecture

The developed Carbon Footprint – Detailed Calculator is a fully client-side web application. This structure ensures that user data is processed directly in the browser without being sent to any server or database, thereby guaranteeing both data privacy and fast computation.

The system is composed of three core technologies:

2.1.1. HTML (HyperText Markup Language)

It forms the basic structure of the tool. Input fields (e.g., input and select tags), informational text boxes, description sections, and output displays are structured via HTML. Form elements are arranged to offer the user an intuitive input experience. Information clutter is prevented by defining separate headings and fields for each category (electricity, transport, heating, diet, etc.).

2.1.2. CSS (Cascading Style Sheets)

A dark mode theme has been preferred for the interface. This provides an advantage in both visual comfort and energy conservation. A card-based layout has been used in the design, visually separating each functional component (e.g., input panel, result card, graph area). CSS Grid and Flexbox are used to ensure the application is responsive across different device sizes (mobile, tablet, desktop).

2.1.3. JavaScript

It is the system's calculation engine. It processes the numerical values received from user inputs, multiplies them by the relevant emission coefficients, calculates the results in tCO_2e/year, and dynamically displays them on the interface. Furthermore, the Canvas API is used to draw bar charts that visualize the contribution of each component to the total emissions. The JavaScript code associates each input element with an ID-based reference. When a value changes, input events are triggered, and the compute() function is instantly re-executed. This allows the user to observe the effect of any change on the total result in real time. This structure reflects the single-page calculator paradigm of modern web applications. Its independence from a server ensures high performance even under low-bandwidth conditions. Moreover, its open-source nature facilitates adaptation to different countries or energy systems. The user input section of the application is illustrated in Figure 1, and the output interface, which displays the calculated results and visualization components, is shown in Figure 2. Both components work together in an interactive unity on the same page, as demonstrated in the combined view in Figure 3.

2.2. User Inputs

The accuracy of the calculation model depends on the scope and quality of the data provided by the user. Therefore, the tool has a multidimensional input structure that represents all significant components of the personal carbon footprint. Each input is an activity data record measuring energy or material consumption, which is multiplied by an emission factor to convert it into the total greenhouse gas equivalent.

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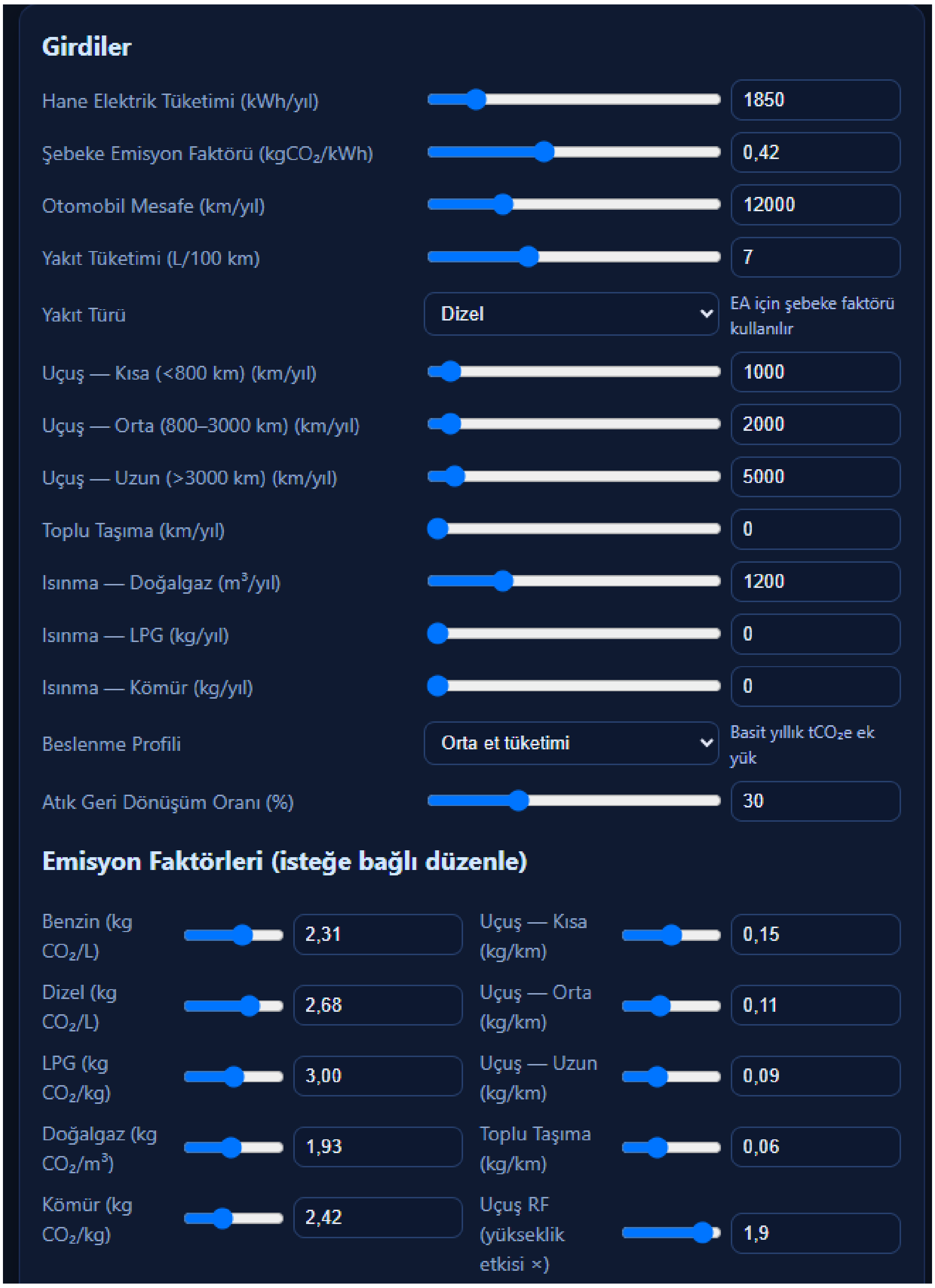

Figure 1. The user input interface.

The user can enter parameters, such as annual electricity consumption, fuel type, automobile and flight distances, heating method, diet profile, and recycling rate, via interactive sliders. At the bottom, emission factors related to fuel and transport types can be optionally edited (Figure 1).

Below, each input category and its role in the calculation is explained in detail:

2.2.1. Electricity Consumption (kWh/year)

This represents the user's annual household electricity consumption. The default value is 3000 kWh, which corresponds to the yearly average consumption level of a 3-4 person family in Türkiye (Equation 1) [16].

$$E_{\text{Electric}} = \frac{\text{Consumption (kWh).Emission Factor (kgCO}_2\text{/kWh)}}{1000} \qquad (1)$$

The grid emission factor can be adjusted by the user (e.g., 0.42 for TR, 0.25 for the EU average, 0.05 for a low-carbon scenario). This feature enables users to visualize the impact of increasing the share of renewable energy in electricity production on individual emissions [17-19].

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2.2.2. Transportation — Automobile Usage

The user's annual driving distance (km) and vehicle type information are collected. Automobile-related emissions are calculated using fuel consumption (in liters per 100 km) and fuel type (gasoline, diesel, LPG, or electric) (Equation 2). Direct emission factors per liter are used for diesel and petrol (2.68 $kgCO_2/L$ and 2.31 $kgCO_2/L$), while an equivalence of approximately 1.6 $kgCO_2/L$ is assumed for LPG. For electric vehicles, indirect emissions are calculated using energy consumption (kWh/100 km) and the grid factor, rather than fuel consumption [17, 20, 21].

$$E_{\text{Vehicle}} = \frac{(\text{Distance}/100).\ \text{Consumption}.\ \text{Emission Factor}}{1000} \quad (2)$$

2.2.3. Flight Distances (km/year)

The user enters the total annual distance traveled for three flight categories: Short haul (<800 km), Medium haul (800–3000 km), and Long haul (>3000 km). A specific emission coefficient is defined for each category ($EF_{s,m,l}$) (e.g., 0.15, 0.11, and 0.09 $kgCO_2/km$). These values are adapted from international aviation data (DEFRA, ICAO). In addition, a radiative forcing (RF) factor is applied to flights. The default RF value is 1.9, representing the additional climate impact of nitrogen oxides and water vapor emitted at high altitudes (Equation 3) [22-24].

$$E_{\text{Flight}} = \frac{(\text{Short}.EF_s) + (\text{Medium}.EF_m) + (\text{Long}.EF_l)}{1000}.\text{RF} \quad (3)$$

2.2.4. Public Transportation (km\year)

This refers to the total distance traveled in public transport vehicles such as buses, subways, or trains. The average emission factor is taken to be 0.06 kg CO_2/km. This value reduces per-person emissions by approximately 4–5 times relative to individual car use; thus, the environmental benefits of sustainable transportation are made visible through this parameter [17, 25, 26].

2.2.5. Heating Sources

The user enters the annual consumption amount for three different heating types: Natural Gas (m^3/year), LPG (kg/year), and Coal (kg/year). The average emission coefficients are set at 1.93, 3.00, and 2.42 $kgCO_2$, respectively. These values are determined based on the fuel's carbon intensity and combustion efficiency (Equation 4) [17, 18].

$$E_{\text{Heating}} = \frac{(\text{Natural Gas}.EF_g) + (\text{LPG}.EF_l) + (\text{Coal}.EF_c)}{1000} \quad (4)$$

2.2.6. Diet Profile

The user's annual dietary habits are assessed in five different categories: High meat consumption, Medium meat consumption, Low meat consumption, Vegetarian, and Vegan. These categories are mapped to fixed values in tCO2e/year, representing the average annual food-related carbon load: 1.7, 1.2, 0.7, 0.4, and 0.25 tCO_{2e}. This approach simplifies the complex supply-chain data on dietary components, providing an educational average. For example, switching from a meat-heavy diet to a vegetarian diet results in an annual reduction of approximately 1 tonne of CO_{2e} [27-29].

2.2.7. Waste Recycling Rate (%)

Waste management is a factor that influences indirect carbon emissions. The user's recycling rate (0–100%) is included in the model as a carbon credit. The default upper limit is 0.3 tCO_{2e}, and at 100% recycling, waste-related emissions are assumed to be zero (Equation 5) [30-32].

$$E_{\text{Waste}} = 0.3\left(1 - \frac{\text{Recycling Rate}}{100}\right) \quad (5)$$

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2.3. Visualization

One of the most important components enhancing the application's user experience is the visualization module. Presenting calculated emission data not only numerically but also graphically provides users with a strong awareness of their carbon footprint profile. In this context, the application uses a bar chart with six columns, each representing a specific emission category (Electricity, Transportation, Heating, Flights, Diet, and Waste). The graphic component is created using the HTML5 Canvas API, which runs directly in the browser. This choice ensures the application remains lightweight and portable, avoiding the need for external libraries (such as Chart.js or D3.js). The chart is located in the application's "Outputs" card and is dynamically updated by the JavaScript draw() function.

Figure 2. The user outputs section.

The total and category-based carbon footprint results (tCO_2e/year) are displayed in cards, and the emission amounts for each category are visualized with a bar chart in the lower section (Figure 2). After

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the calculation process is completed, the compute() function passes the result to the draw() function. This function performs the following steps.

2.3.1. Data Preparation

The emission amount (tCO_2e/year) for each category is retrieved from the parts object. These values are collected in an array. The category labels (Electricity, Transportation, Heating, Flight, Diet, Waste) are defined in the same order.

2.3.2. Scaling and Normalization

The highest value (max) is identified, and the height of the other columns is proportionally scaled accordingly. This ensures the entire chart is dynamically scaled while maintaining visual integrity.

2.3.3. Color Coding

Each column is colored using a predefined palette to give the user an intuitive color association: Electricity (Cyan, (#22d3ee)), Transportation (Blue, (#60a5fa)), Heating (Green, (#34d399)), Flight (Orange, (#f59e0b)), Diet (Purple, (#a78bfa)), Waste (Red, (#ef4444)). This color choice enables users to quickly perceive category distinctions and establish a visual connection among themes such as energy, transportation, and diet.

2.3.4. Labeling

The category name is displayed beneath each column, and the numerical value (if desired) can be shown at the top. The font automatically scales according to the system's interface font, ensuring readability across all devices.

2.3.5. Dynamic Update and Interactivity

The chart is updated in real-time. When the user makes a change to any input (e.g., Fuel Consumption or Grid Emission Factor), the results are instantly recalculated, and the chart is redrawn. This interaction allows the user to directly observe the causal relationship: for instance, they immediately notice the Electricity column visibly shortening as the grid factor is reduced from 0.42 to 0.25. This feature transforms the visualization from merely a presentation tool into an instructive simulation tool. Through an "experimentation" approach, users can intuitively learn the impact of lifestyle changes on their carbon footprint.

2.3.6. Switching Between Grid Scenarios

Three predefined scenario buttons located below the chart allow calculations based on different energy mix assumptions: TR Grid (0.42 $kgCO_2$/kWh): Represents Türkiye's current electricity generation structure, EU Average (0.25 $kgCO_2$/kWh): Reflects the average value in European countries, where the share of renewable energy is higher, Low Carbon (0.05 $kgCO_2$/kWh): A projected value for a fully renewable or nuclear-backed grid scenario. When the user clicks these buttons, the system automatically updates the relevant value and redraws the graph. This enables the individual to directly visualize the effect of energy transition policies on their personal carbon footprint.

2.3.7. Accessibility and Aesthetic Design

The chart is designed not only for visual users but also in accordance with accessibility principles. The aria-label attribute is defined within the canvas element, providing screen readers with the description: "Emissions graph by component." Furthermore, color contrasts are selected to comply with WCAG guidelines, allowing users with low vision to distinguish color differences. In conclusion, this visualization module facilitates the transfer of both quantitative and qualitative information, maintaining numerical accuracy while enabling users to form emotional and cognitive connections. In this sense, the tool goes beyond being a technical calculator and turns carbon awareness into a visual experience.

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3. Results and Discussion

This section discusses the technical and pedagogical aspects of the developed Carbon Footprint – Detailed Calculator tool. The tool’s strengths, limitations, and potential future development suggestions are addressed. The objective is to evaluate this digital solution’s potential for creating environmental awareness and its role in sustainability education in a multidimensional manner.

3.1. Strengths of the Model

3.1.1. Fully Browser-Based Structure and Data Security

The most significant advantage of the application is that it operates entirely on the client-side. All calculations are performed within the user's browser, eliminating the need to send data to a server. This feature protects personal data privacy and provides an anonymous user experience. This architecture is crucial for the ethical use of data, particularly in applications involving sensitive data, such as environmental and energy data.

3.1.2. Real-Time Calculation and Feedback

Due to the model's dynamic structure, results are recalculated immediately when the user changes any parameter. This real-time feedback transforms the user from a passive observer into an active participant in an interactive learning process. For example, immediately seeing on the graph how electricity-related emissions decrease as the grid emission factor is reduced from 0.42 to 0.25 makes an abstract concept concrete. This is a strong feature that develops systems thinking and causal awareness within the tool.

3.1.3. Parametric and Flexible Structure

The application's entire calculation model is parametric, meaning that inputs such as emission factors, energy conversion rates, and the RF (radiative forcing) coefficient can be modified by the user. This flexibility transforms the tool from merely a “calculator” into an experimental simulation platform. Users can test different country scenarios or technological transformation assumptions to observe how their personal carbon footprint changes in response to these conditions. This makes the application suitable for use in both academic courses and climate literacy education.

3.1.4. Simple, Lightweight, and Accessible Design

The application's codebase is built entirely with HTML, CSS, and JavaScript; no additional frameworks or external libraries are used. This results in a very small file size, enabling the application to function even when offline. Furthermore, the dark-themed and simple interface design reduces visual clutter, providing a user experience that adheres to accessibility standards (WCAG).

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Figure 3. General view of the Carbon Footprint—Detailed Calculator

The input and output components are integrated on a single page within the interface, allowing the user to observe the effects of parameter changes in real time. The visualization is dynamically generated using the HTML5 Canvas API (Figure 3).

3.2. Environmental Awareness and Educational Impact

Digital carbon calculators have the potential to go beyond being merely quantitative tools, creating individual awareness and encouraging behavioral change. According to the literature on environmental psychology, individuals' adoption of sustainable behaviors depends not only on information but also on feedback and self-awareness. This is where carbon footprint calculators intervene: when the user sees the concrete environmental impact of their lifestyle in numerical terms, the abstract concept of carbon emissions becomes a personal reality. The application clearly indicates to the user which categories have the greatest impact, thereby fostering prioritization awareness. For instance, when a user observes that 40% of their total emissions originate from transportation, they may question their transportation-related behavior. This awareness affects three basic levels: learning which actions produce how much carbon emission (cognitive), internalizing the environmental burden of one's own lifestyle (emotional), and putting the acquired knowledge into practice through behavior (behavioral transformation). When users observe that even small changes produce measurable results, they develop a sense of self-efficacy (Bandura's theory), thereby completing the information-awareness-behavior chain [33, 34].

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The carbon footprint calculator is a valuable teaching tool for both individual users and educational institutions. It can concretize topics such as energy, climate, and environment in environmental sciences, energy systems, or geography courses at the university and high school levels. Students can calculate their individual carbon footprints by entering their own life data and then comparing the results to draw inferences, such as "Which lifestyle is lower carbon?" The tool thus creates an interactive laboratory environment that fosters data literacy, systems thinking, and critical environmental consciousness. While traditional ecological education often relies on passive knowledge transfer, digital calculators empower users to become active participants. This is a model of awareness through experience, not awareness through learning. Through online calculators, users can compare carbon profiles in their regions, thereby observing differences at local and global scales. Such experiences elevate consciousness of sustainable development from the individual to the societal level.
Finally, the application's potential for social impact is also significant. The ability of users to share their results on social media, or to organize carbon-reduction competitions, could help foster collective awareness. Seeing their own results on the same platform empowers a sense of shared responsibility among different segments of society, including students, employees, municipal staff, and civil society members. In this respect, carbon calculators can be considered not only tools that increase environmental consciousness but also digital extensions of participatory environmental education.

4. Conclusion

This study presented a lightweight, web-based carbon footprint calculator designed to provide an accessible and interactive means for individuals to estimate their annual emissions. The Carbon Footprint – Detailed Calculator extends environmental calculation tools beyond expert users by translating complex scientific processes into a clear and intuitive user experience. Through real-time feedback and categorized visualizations, the application enables users to interpret their emission profiles and supports effective environmental communication by translating abstract numerical values into interpretable insights.

Technologically, the fully browser-based architecture ensures high performance and usability even on low-spec devices, supporting digital inclusion. Educationally, the tool functions as an interactive simulation environment that promotes experiential learning by allowing users to observe immediate cause–and–effect relationships when modifying input parameters. In this respect, it aligns with the principles of active learning in sustainability education.

The application contributes to the United Nations Sustainable Development Goals, particularly SDG 13 (Climate Action), by encouraging individual engagement with climate mitigation, while also supporting SDG 4 (Quality Education) and SDG 12 (Responsible Consumption and Production) through the promotion of environmental literacy and awareness of consumption-related impacts [35–38].

Nevertheless, the model relies on average emission factors from the literature, which may not fully reflect regional and temporal variations. The simplified representation of diet, waste, and lifestyle variables prioritizes accessibility over high-precision accounting, and the browser-based architecture does not support long-term storage of user data. Consequently, the tool emphasizes educational value rather than exact carbon accounting.

Future work may enhance the tool's impact by enabling the sharing of results, introducing goal-setting mechanisms, and integrating the calculator into curricula at the secondary and higher education levels. Overall, the Carbon Footprint – Detailed Calculator demonstrates that a simple, open-source web application can meaningfully contribute to environmental awareness and digital sustainability education.

The calculator is publicly accessible at: https://aliakyuz12.github.io/karbon-ayak-izi-hesaplayici/

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DOI: 10.62301/usmtd.1822483

5. References

[1] S. Legg, “IPCC, 2021: Climate change 2021—the physical science basis,” Interaction, vol. 49, no. 4, pp. 44–45, 2021.

[2] D. Rapp, “Estimate of temperature rise in the 21st century for various scenarios,” IgMin Res., vol. 2, no. 7, pp. 564–569, 2024.

[3] A. Arneth, “Climate change: Status and trends, and a land-ecosystem perspective,” Zeitschrift für Menschenrechte, vol. 18, no. 1, pp. 7–12, 2024.

[4] X. Malcher, F. C. Tenorio-Rodriguez, M. Finkbeiner, and M. Gonzalez-Salazar, “Decarbonization of district heating: A systematic review of carbon footprint and key mitigation strategies,” Renewable and Sustainable Energy Reviews, vol. 215, p. 115602, 2025.

[5] N. K. Arora and I. Mishra, “Sustainable development goal 13: recent progress and challenges to climate action,” Environmental Sustainability, vol. 6, no. 3, pp. 297–301, 2023.

[6] M. Olczyk and M. Kuc-Czarnecka, “European Green Deal Index: A new composite tool for monitoring European Union’s Green Deal strategy,” Journal of Cleaner Production, vol. 495, p. 145077, 2025.

[7] “Paris Agreement,” in Report of the Conference of the Parties to the United Nations Framework Convention on Climate Change (21st Session, 2015: Paris), Getzville, NY, USA: HeinOnline, 2015.

[8] D. Pandey, M. Agrawal, and J. S. Pandey, “Carbon footprint: current methods of estimation,” Environmental Monitoring and Assessment, vol. 178, no. 1, pp. 135–160, 2011.

[9] S. Melanta, E. Miller-Hooks, and H. G. Avetisyan, “Carbon footprint estimation tool for transportation construction projects,” Journal of Construction Engineering and Management, vol. 139, no. 5, pp. 547–555, 2013.

[10] J. Solís-Guzmán, C. Rivero-Camacho, D. Alba-Rodríguez, and A. Martínez-Rocamora, “Carbon footprint estimation tool for residential buildings for non-specialized users: OERCO2 project,” Sustainability, vol. 10, no. 5, p. 1359, 2018.

[11] E. Edstrand, “Making the invisible visible: How students make use of carbon footprint calculator in environmental education,” Learning, Media and Technology, vol. 41, no. 2, pp. 416–436, 2016.

[12] J. Mulrow, K. Machaj, J. Deanes, and S. Derrible, “The state of carbon footprint calculators: An evaluation of calculator design and user interaction features,” Sustainable Production and Consumption, vol. 18, pp. 33–40, 2019.

[13] C. Auger et al., “Open-source carbon footprint estimator: Development and university declination,” Sustainability, vol. 13, no. 8, p. 4315, 2021.

[14] J. C. Brazier, Mobile Carbon Footprinting: Sensing and Shaping the Carbon Emissions of Daily Activities Using Digital Technologies, Ph.D. dissertation, Massachusetts Institute of Technology, 2021.

[15] J. Mariette et al., “An open-source tool to assess the carbon footprint of research,” Environmental Research: Infrastructure and Sustainability, vol. 2, no. 3, p. 035008, 2022.

[16] Elektrik Mühendisleri Odası (EMO), “Çevre ve İklim Değişikliği,” [Online]. Available: https://www.emo.org.tr/genel/bizden_detay.php?kod=135116&tipi=2&sube=

[17] K. Kumaş, A. Ö. Akyüz, M. Zaman, and A. Güngör, “Sürdürülebilir bir çevre için karbon ayak izi tespiti: MAKÜ Bucak Sağlık Yüksekokulu örneği,” El-Cezeri, vol. 6, no. 1, pp. 108–117, 2019.

***Sorumlu Yazar/Corresponding Author:** aakyuz@mehmetakif.edu.tr

ISSN: 2618-6055 / 9, (2), 290 – 302, 2025
DOI: 10.62301/usmtd.1822483

[18] T.C. Enerji ve Tabii Kaynaklar Bakanlığı, "Emisyon Faktörleri 2022," [Online]. Available: https://enerji.gov.tr//Media/Dizin/EVCED/tr/%C3%87evreVe%C4%B0klim/%C4%B0klimDe%C4%9Fi%C5%9Fikli%C4%9Fi/EmisyonFaktorleri/2022_Uretim_Tuketim_EF.pdf

[19] J. Bastos, F. Monforti-Ferrario, and G. Melica, "GHG emission factors for electricity consumption," European Commission, Joint Research Centre (JRC), Dataset, 2024. [Online]. Available: http://data.europa.eu/89h/919df040-0252-4e4e-ad82-c054896e1641

[20] S. Tırınk and H. A. Özen, "Determination of carbon footprint at institutions of higher education: The case of the Iğdır University," Journal of the Institute of Science and Technology, vol. 13, no. 4, pp. 2532–2545, 2023.

[21] S. Ören and S. Kocabaş, "İklim değişikliği ile mücadelede kurumsal karbon emisyon farkındalığını arttırma: Zonguldak Bülent Ecevit Üniversitesi Devrek Meslek Yüksekokulu örneği," Black Sea Journal of Engineering and Science, vol. 6, no. 4, pp. 363–368, 2023.

[22] K. Kumaş, H. H. Aksu, O. İnan, A. Akyüz, and A. Güngör, "Estimation of carbon dioxide emissions from airplanes: a case study of a Turkish airport," in AIP Conference Proceedings, vol. 2178, no. 1, p. 030043, AIP Publishing LLC, 2019.

[23] K. Kumaş, O. İnan, A. Ö. Akyüz, and A. Güngör, "Muğla Dalaman Havalimanı uçaklardan kaynaklanan karbon ayak izinin belirlenmesi," Academic Platform–Journal of Engineering and Science, vol. 7, no. 2, pp. 291–297, 2019.

[24] F. Cao, T. Q. Tang, Y. Gao, F. You, and J. Zhang, "Calculation and analysis of new taxiing methods on aircraft fuel consumption and pollutant emissions," Energy, vol. 277, p. 127618, 2023.

[25] TÜİK, Turkish Greenhouse Gas Inventory 1990–2022: National Inventory Document for submission under the United Nations Framework Convention on Climate Change, Nov. 2024.

[26] T.C. Enerji ve Tabii Kaynaklar Bakanlığı, "Ulusal Sera Gazı Emisyon Envanteri Ek 1," [Online]. Available: https://enerji.gov.tr/Media/Dizin/EVCED/tr/%C3%87evreVe%C4%B0klim/%C4%B0klimDe%C4%9Fi%C5%9Fikli%C4%9Fi/UlusalSeraGaz%C4%B1EmisyonEnvanteri/Belgeler/Ek-1.pdf

[27] P. Scarborough et al., "Dietary greenhouse gas emissions of meat-eaters, fish-eaters, vegetarians and vegans in the UK," Climatic Change, vol. 125, no. 2, pp. 179–192, 2014.

[28] B. Kovacs, L. Miller, M. C. Heller, and D. Rose, "The carbon footprint of dietary guidelines around the world: a seven country modeling study," Nutrition Journal, vol. 20, no. 1, p. 15, 2021.

[29] L. Rodríguez-Jiménez, M. Romero-Martín, T. Spruell, Z. Steley, and J. Gómez-Salgado, "The carbon footprint of healthcare settings: a systematic review," Journal of Advanced Nursing, vol. 79, no. 8, pp. 2830–2844, 2023.

[30] A. B. S. Schott and T. Andersson, "Food waste minimization from a life-cycle perspective," Journal of Environmental Management, vol. 147, pp. 219–226, 2015.

[31] European Environment Agency (EEA), Municipal Waste Management Across European Countries, Report No. 12/2021, 2021.

[32] United States Environmental Protection Agency (EPA), Household Carbon Footprint Calculator: Assumptions and References, 2022.

[33] S. G. Burakgazi, "The ecological model of human development," in Exploring Adult Education Through Learning Theory, IGI Global, pp. 325–342, 2025.

***Sorumlu Yazar/Corresponding Author:** aakyuz@mehmetakif.edu.tr

ISSN: 2618-6055 / 9, (2), 290 – 302, 2025
DOI: 10.62301/usmtd.1822483

[34] A. Rumjaun and F. Narod, “Social learning theory—Albert Bandura,” in Science Education in Theory and Practice: An Introductory Guide to Learning Theory, Cham: Springer Nature Switzerland, pp. 65–82, 2025.

[35] United Nations, “Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all,” [Online]. Available: https://sdgs.un.org/goals/goal4

[36] United Nations / Global Goals, “Goal 13: Climate Action,” [Online]. Available: https://globalgoals.org/goals/13-climate-action/

[37] A. A. Vărzaru, C. G. Bocean, M. Gheorghe, D. Simion, M. G. Mangra, and A. A. Cioabă, “Assessing the impact of digital technologies on the Sustainable Development Goals within the European Union,” Electronics, vol. 13, no. 23, p. 4695, 2024.

[38] D. Hariyani, P. Hariyani, and S. Mishra, “Digital technologies for the Sustainable Development Goals,” Green Technologies and Sustainability, p. 100202, 2025.

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