Ann. For. Res. 66(2): 264-284, 2023
ISSN: 18448135, 20652445

ANNALS OF FOREST RESEARCH
www.e-afr.org

THE CARBON FOOTPRINT LIFE BEHAVIOUR OF STUDENTS' IN UNIVERSITIES IN THE NEW ERA: A CASE STUDY OF HANGZHOU MEDICAL COLLEGE

Li Ruirui[1†], Shao Ji[2†], Wang Xinya[1], Yu Zecheng[1], Ye Wenjing[1], Ou Chun[1], Zhang Yuheng[1], Dai Fangwei[2,3,4], Ying Huazhong[2,3,4], Shi Qiaojuan[2,3,4*], Han Wei[2,3,4*]

[1]School of Medical Imaging, Hangzhou Medical College, Hangzhou, China
[2]Center of Laboratory Animal, Hangzhou Medical College, Hangzhou, China
[3]Zhejiang Key Laboratory of Laboratory Animal and Safety Research, Hangzhou, China
[4]Engineering Research Center of Novel Vaccine of Zhejiang Province, Hangzhou, China
[†]These authors contributed equally to this work
[*]**Correspondence to:** Shi Qiaojuan and Han Wei, Center of Laboratory Animal, Hangzhou Medical College, Hangzhou, China; Zhejiang Key Laboratory of Laboratory Animal and Safety Research, Engineering Research Center of Novel Vaccine of Zhejiang Province, Hangzhou, China, E-mail: shiqiaojuan@163.com, hanwei3612@163.com

1. Abstract

The development of an ecological civilisation is a key component of China's 'five-in-one' strategic approach and is essential to its creation of a human destiny community. Based on the abundance of China's energy resources and its planned step-by-step implementation of carbon reduction efforts, its 20th Party Congress proposed the country's pursuit of carbon peak and carbon neutrality. Chinese college students have a crucial duty to help realise this 'dual-carbon' mission as participants and proponents of this new journey. This study collected data from students at Hangzhou Medical College to examine the elements that determine college students' individual and collective carbon footprints, using comparative, descriptive and structural analyses. The study demonstrated the variety in the spatial distribution of carbon footprints across many campuses, the lack of motivation to live a low-carbon lifestyle. To construct an environmentally-friendly and low carbon campus, we propose four recommendations to decrease the individual carbon footprints of students on campus. To establish the groundwork for the future execution of the 'dual-carbon' strategic aim of China, this research encourages college students to start from small parts of their daily life, establish the idea of low-carbon life and actively participate in the construction of low-carbon life.

2. Key words: Ecological civilisation; College students; Carbon footprint; Green; Dual-carbon strategy

3. Introduction

On September 22, 2020, General Secretary Xi Jinping announced at the 75th session of the United Nations General Assembly that China would strive to achieve its dual-carbon goals of having peak carbon dioxide (CO_2) emissions by 2030 and reaching carbon neutrality by 2060. In 2021, the Opinions of the Central Committee of the Communist Party of China and the State Council on the Integrity and Accuracy of Fully Implementing the New Development Philosophy and Doing a Good Job in Carbon Peak and Carbon Neutrality (hereinafter referred to as 'the Opinions') and the Peak Carbon Action Plan for the Period up to 2030 (hereinafter referred to as 'the Plan') were

released. The Opinions argue for the necessity of implementing 'national coordination, conservation priority, two-wheel drive, [and] internal and external smooth risk prevention' to build a low-carbon and recycling development of the economic system and a clean, low-carbon, safe and efficient energy system, to promote the country's economic and social development through its overall green transformation and to develop a detailed phased target for achieving Peak Carbon by 2030 on track.(Geng, Zhu and Maimaituerxun 2022). Indeed, a series of studies such as from low carbon to carbon neutrality: A bibliometric analysis of the status, evolution and development trend has shown that low-carbon development is a prerequisite for carbon neutrality (Zhang, Hu, Mu et al. 2022).

The promotion of the idea of green energy conservation and environmental preservation at the level of campus culture began in 2009 with the suggestion of a low-carbon campus, for the implementation of low-carbon policies, the implementation of sustainable development in universities is very important. (Filho et al. 2023). According to Wang et al. (2023), China's colleges and universities' total energy consumed account for approximately 10% of the total energy consumed by its urban residents, and the energy consumption per person in university is roughly four times more than that of urban residents. The promotion of the ideas of green energy conservation as well as environmental preservation at the level of campus culture began in 2009 with the suggestion of a low-carbon campus. (Filho et al. 2023) A common way to measure the sustainability of a campus is through carbon footprinting, which is a life-cycle approach to studying the CO_2 emission processes associated with a product's life cycle or activities, or indirectly (Cederberg et al. 2019; Filimonau et al. 2021a). A carbon footprint, or an 'ecological footprint', refers to the total amount of climate change-related gases emitted by human beings in their production and consumption activities. Unlike other carbon emission studies, carbon footprinting is a life-cycle approach to studying the carbon emission processes associated with a product's life cycle or activities, or indirectly, and is a common way to measure the sustainability of a campus. Low CO_2 emission is a key feature of sustainable campus development, and university students have the important mission of helping build a green and economical society (Zheng et al. 2021; Yin et al. 2022b). Therefore, this study investigates carbon footprints in various aspects of campus life, assesses college and university students' shortcomings in leading low-carbon lifestyles and offers reference samples for achieving China's dual-carbon goals in the long term. It is also in line with China's Five in One strategic orientation and has significant implications for reducing carbon footprint.

4. Materials and Methods

4.1. Survey on the current personal carbon footprints

The target of this research was in colleges and universities in Zhejiang Province but mainly in Hangzhou Medical College. A survey was conducted among them using a questionnaire to calculate their personal carbon footprint and to analyse the current state of their low-carbon lives. The questionnaire covered many aspects of their knowledge of carbon footprints, daily clothing,

food, housing, transportation and others (refer to Appendix 1 for the questionnaire). It specifically addressed three areas of inquiry:

a. Relationship between college students' understanding of carbon footprint and their willingness to participate in low-carbon action at all grades;

b. Statistical table of college students' daily travel modes and travel intentions; and

c. Whether they use disposable chopsticks for takeout.

A total of 912 online questionnaires were distributed to 723 female college students (79.28%) and 189 male college students (20.72%), and all of them were effectively recovered, with a validity rate of 100%.

4.2. Overview of the carbon footprint of universities

To explore, summarise and analyse the interconnection and role of each single sample carbon footprint between campus infrastructure planning and the campus living environment, the necessary energy consumption and carbon footprint of the campus were also investigated (Yin et al. 2022a).

5. Results

5.1. Phenomenon and analysis of the personal carbon footprint of college students

Grade	Very knowledgeable and mindful about participating in low-carbon actions	Basic understanding but no attention to participating in low-carbon action	Don't know but want to participate in low-carbon action	Do not understand and do not want to participate in low-carbon action
Freshman year	19.66%	44.47%	34.64%	1.23%
Sophomore year	17.86%	43.68%	37.36%	1.10%
Junior	20.16%	36.29%	41.94%	1.61%
Senior	17.65%	47.06%	35.29%	0.00%

Table 1: Relationship between college students' understanding of carbon footprint and willingness to participate in low-carbon action in all grades.

Table 1 shows that most (but less than half) of the students in each year level had either only a basic understanding of carbon footprint but did not participate in low-carbon action or had no

knowledge of carbon footprint but wanted to participate in low-carbon action. Only about 20% of them had a thorough understanding of carbon footprint and actively participated in low-carbon actions. These data are consistent with the findings in past studies that most college students have a limited understanding of the concept of carbon footprint and lack knowledge about low-carbon lifestyles. However, in this study, only about 1% of the students refused to participate in daily low-carbon activities, though, that a high percentage of students yearly did not engage in low-carbon actions even though they had a basic understanding of carbon footprint.

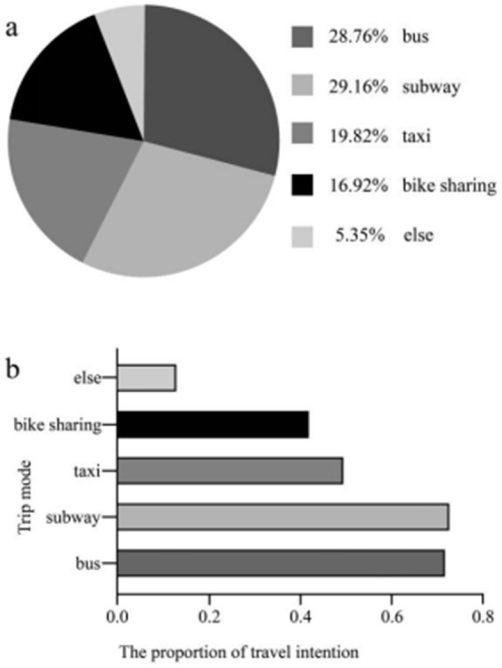

Figure 1: Statistical Table of College Students' daily travel mode and travel Intention.

As per the students' daily commuting methods, Figure 1a and Figure 1b show that most of the students used or intended to use subway trains and public buses (29.16% and 28.76%, and 72.92% and 71.93%, respectively), followed by taxis (19.82% and 49.56%, respectively). The data on taxis show the increasing popularity of ride-hailing services among students, most likely due to their timeliness and efficiency. Additionally, in Figure 1b, shared bicycles account for 42.32% of the choices, while only 13.38% chose to use other modes of transport or to walk. The survey results indicate that college students as a whole have a strong environmental awareness when it comes to choosing low-carbon transportation options.

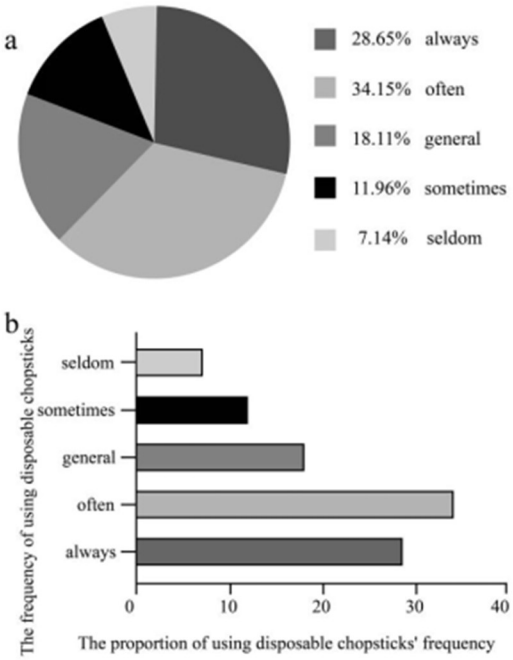

Figure 2: Whether disposable chopsticks are selected for takeout.

On the frequency of the students' use of disposable chopsticks when ordering takeout, figure 2b show that 62.8% of them always or frequently used disposable chopsticks, while the remaining students had a lower frequency of use of disposable chopsticks. The enormous waste caused by the extensive use of disposable chopsticks on the country's forestry resources cannot be ignored.

frequency	Average number of clothes purchased per year (pieces)	Average daily intake of rice (bowl)	Average number of eggs consumed per week	Average milk intake per week (in bags)	Average weekly meat intake (servings)
quantity	8.99	2.18	4.46	4.14	9.66

Table 2: Statistics of clothing, food, housing, and transportation of College Students

Based on the data shown in Table 2 on the individual students' volumes of clothes purchased and of rice, egg, milk and meat intake, the average annual campus carbon footprint per student was calculated as 24,988.25 kg. There are many methods to calculate the carbon footprint. At present, the widely used methods are carbon calculator method, process analysis and input-output method. The carbon calculator method is usually used to calculate the carbon dioxide emissions generated by the daily energy consumption of individuals and families, so we use this way to calculator, and then we calculator how many trees need to be planted to compensate according to the absorption of 111kg carbon dioxide by fir in 30 years, so as to show the chain of college students' daily

consumption-CO_2 emissions-carbon compensation (carbon footprint calculator website is carbonstop.net). Of this figure, the CO_2 emissions from the disposable chopsticks used by each student per year was 2.08 kg (0.008% of the total); the CO_2 emissions from the rice, eggs, milk and meat consumed by each student per year was 780 kg (3.12%); and the CO_2 emissions from the clothing purchased by each student per year was 62.93 kg (0.25%). In terms of the building CO_2 emissions, those from electricity consumption were 510 kg (2.05%); and from water, 23,633.24 kg (94.58%), of which 19–24% was for the teaching areas and 76–81% was for domestic water use. Thus, water use has the highest proportion of CO_2 emissions in-campus, followed by the intake of rice, eggs, milk and meat, and by electricity consumption.

5.2. Phenomenon and analysis of the carbon footprint of universities

5.2.1 Characteristics of carbon footprint spatial distribution on-campus: The Binjiang (branch campus) of Hangzhou Medical College spans 167.2 acres and is divided into three areas: teaching, sports and ecology. As it is located in the Binjiang Higher Education Park in Hangzhou, it benefits from convenient transportation and a mature commercial and cultural environment. In the context of the COVID-19 pandemic prevention and control, the emission of carbon footprints has decreased compared to normal circumstances. The lifestyle of students in the Lin'an campus area mainly revolves around on-campus activities, with fewer activities off-campus. Therefore, the proportion of off-campus carbon footprints in the total carbon footprint of this campus is small(Filimonau et al. 2021b).

Thus, the functional layout of campus buildings affects the carbon footprint on-and off-campus in many ways, and the total amount of carbon footprint generated varies across functional areas, which is usually determined by the building attributes, functional structure, population density, and mobility trajectories(Li et al. 2022). If the school is near the subway entrance or food street, the carbon footprint on campus may be smaller than that on campus. If the school has functional areas that provide catering, the carbon footprint on campus may be higher than that on campus.

5.2.2. Carbon footprint characteristics of campus transportation modes: Based on the average annual personal transportation carbon footprints of the students on-campus, the total transportation carbon footprint was 114.12kg. This footprint had both on-campus and off-campus components. For the on-campus footprint, most of the students walked and biked. For the off-campus footprint, the annual per capita carbon CO_2 emissions from bus usage were 4.05kg (3.55% of the total CO_2 emissions), and from subway usage 16.82kg (14.74%). The highest CO_2 emissions were from private cars, which reached 93.25kg (81.72%). Based on these data, we can draw a preliminary conclusion that green transportation methods, such as walking and public transportation, are beneficial for the development of a low-carbon campus, while vehicles with high CO_2 emissions, such as cars, pose significant challenges to the establishment of a low-carbon society.

5.3 Main problems between the carbon footprint and the low-carbon living behaviour of college students

This study found that the main issues among the college students in leading a low-carbon lifestyle were their lack of awareness of carbon footprint and low-carbon mindset, and their inadequate skills for low-carbon living. They generally had a low-carbon mindset, and their awareness of low-carbon living was not strong enough to allow them to implement related behaviours in their daily lives. Very few of them took measures to reduce CO_2 emissions, such as by unplugging their devices before leaving, while most of them either lacked the willingness to do so. As a result, a significant amount of electricity is wasted. In conclusion, the low-carbon and environmentally friendly behaviours of college students need to be strengthened (Lizana et al. 2021).

6. Discussion

6.1 Advocating measures for reducing the personal carbon footprint of college students

The survey conducted on the behaviour of college students and the statistical results of their carbon footprint data, show that most of them understood carbon footprint, but few of them engaged in low-carbon actions. Based on the data obtained from statistical surveys, we can draw a preliminary conclusion that green transportation methods, such as walking and public transportation, are beneficial for the development of a low-carbon campus, while vehicles with high CO2 emissions, such as cars, pose significant challenges to the establishment of a low-carbon society. To build campus in support of the realization of China's dual-carbon strategy, college students must actively participate in low-carbon environmental protection by implementing the following recommendations. In conclusion, the low-carbon and environmentally friendly behaviours of college students need to be strengthened(Lizana et al. 2021).

6.1.1. Remodelling of students' diets: As food is a daily consumable, its production and consumption result in significant CO2 emissions, making it an important factor of climate change(Zhao et al. 2020). The survey conducted among students at Hangzhou Medical College's Binjiang and Lin'an campuses revealed that more than half of the university students lacked awareness of low-carbon diets. Most of them relied on their personal preferences for their meals, primarily for meat. Research has shown that diets rich in vegetables generally have better environmental conditions than diets that consist mainly of meat, especially from ruminant animals(González-García et al. 2018). Therefore, university students must adjust their daily dietary structure towards a low-carbon approach, by incorporating more green vegetables while still meeting the recommended intake of meat. According to Fernández and Mónica (Fernández et al. 2020), individual sustainable habits are not directly correlated with nature or environmental preservation. However, when individual actions are combined, they can have an impact on the global ecosystem. In other words, the collective actions of individuals have a global influence, directly related to consumption, resource usage and the destruction of nature and its ecosystems. Thus to achieve carbon neutrality goals, efforts are needed not only from relevant institutions or administrative levels but also from individuals.

6.1.2. Enhancing environmental protection awareness: In climate change, CO2 emissions account for the largest proportion (76.6%) of all human-caused Greenhouse Gas (GHG) emissions. To

reduce CO2 emissions, low-carbon behaviours are recommended, such as purchasing green products and conserving energy, in contrast to actions that do not reduce CO2 emissions and that are thus not considered low-carbon, such as recycling waste and water pollution. The concept of low-carbon behaviours goes beyond legal standards, allowing individuals to make their own decisions on whether to take action (Field and Barros 2014; Chen and Li 2019; Lin and Yang 2022).

Hines et al. (1986) suggested that the willingness to engage in environmentally friendly behaviour is influenced by environmental knowledge and positively impacted by conformity (Fernández et al. 2020). Individuals can exercise self-restraint in relation to sources of high CO2 emissions by assessing their carbon footprint using a carbon footprint calculator. Data show that consistently using a carbon footprint calculator can help mitigate global warming, and thus, reduced carbon footprints are key indicators of sustainable development.

The carbon footprint calculator shows that evaluating emission methods of CO2 emission reduction can enhance college students' understanding of how they can help reduce GHG emissions (Wagner et al. 2021).

To further encourage the development of good low-carbon habits among college students, colleges and universities can implement measures such as restricting electricity usage and implementing tiered charges for water and electricity. These measures are important because electricity and water are the main aspects of energy consumption in universities. For example, universities use high-power appliances such as air conditioners. Thus, relevant departments should take measures to intervene in daily high-energy consumption behaviours of student groups, such as cut off power sometimes and standardised electricity usage periods(Almeida, Sousa, and Silva 2021; Kerem 2022).

To further reduce individual carbon footprints, campuses need to strengthen their promotion of low-carbon concepts such as by analysing date related to college students' carbon footprints, working with university clubs and student service centres, and with the school's youth league committee, to promote the concept of an ecological civilisation and low-carbon environmental protection. At the same time, schools can use social media platforms such as WeChat and Douyin to cultivate a 'frugal and green campus' culture, create a low-carbon campus atmosphere, visualise CO2 emissions through carbon footprint calculators, cultivate low-carbon environmental protection habits and promote low-carbon travel (Gao et al. 2022; Yan 2022).

Schools should also introduce a curriculum related to ecological ethics education. Climate change, CO2 emissions, and other concepts impact the life of each individual. Sometimes, the ooffering of low-carbon-related courses in universities can effectively bridge the gap between institutions and the environment (Cordero, Centeno, and Todd 2020; Malan et al. 2020). However, in reality, most

universities still focus on traditional ideological and political education, lacking a comprehensive value system that also cultivates students' sense of responsibility for leading a low-carbon way of life. Students generally also have a vague understanding of and lack of interest in new concepts such as carbon footprints. Classroom lectures and textbooks can only create environmental awareness on paper, making it difficult to practically implement energy-saving and CO2-emission-reduction practices. Therefore, it is necessary for schools to introduce relevant low-carbon environmental courses and establish a related systematic training model while considering the practical CO2 reduction perspective.

6.1.3. School logistics management reform: 'Universities, as the cradle for nurturing future talents of our country, bear a significant responsibility(Yan, Liu, et al.) CO2 emissions and low-carbon research' (Xu and Chang 2018,Vol. 10 Issue 5, p63-68). Although the COVID-19 pandemic has limited campus activities for college students and thus has reduced schools' resource consumption, the per capita ecological budget deficit of Hangzhou university students - while slightly lower than the national average - is still significantly higher than the global ecological budget deficit. Therefore, universities need to continuously optimise their campus management models to help achieve the goals of energy conservation, CO2 emission reduction and the development of a low-carbon circular economy (Cui and Zhang 2022; Ramakrishna and Jose 2022). Campus planning must establish green facilities according to the needs of students, strengthen the maintenance of campus green spaces and promote the sustainable development of an environmental protection campus(Li, Ni, and Dewancker 2019).

Other measures that schools can adopt to create low-carbon campuses are the optimization of their catering logistics management to reduce the use of disposable tableware, the improvement of their energy use through digital reform, and increasing the proportion of their renewable energy consumption(Liu, Shang, and Liu 2023), as well as their adoption of tree planting to control the carbon footprint of students on-campus while increasing the existing biological sequestration of carbon to optimise the low-carbon circular economic model (Yañez, Sinha, and Vásquez 2019). The relevant departments need to regularly carry out green protection and green value activities, further increase the green coverage area of the campus, reasonably distribute seedling species and ratios, and adopt composite agricultural and forestry techniques to improve the amount of carbon sequestered by green plants, to create a low-carbon campus(Way and Long 2015; Wang, Wang, Qu, et al. 2021). Moreover, the student union and various other organizations could promote a series of environmental activities, such as the "Five Waters Co-governance" initiative, to reduce GHG emissions and CO2 emissions(Muqeet et al. 2022).

6.1.4. Participation of all people in local government enterprises and private organisations: At the government level, efforts are being made to strengthen the guidance in the development of a low-carbon consumption market and to strike a balance between economic input costs and the benefits of energy conservation as well as CO2 emission reduction(Yang et al. 2019; Zhang, Hu, et al.

2022). These include establishing a comprehensive CO2 emissions trading system to regulate the market and compel companies to reduce their CO2 emissions. When formulating carbon tax policies, the government should add appropriate mechanisms for carbon tax recycling to minimize the impact on related industries and to achieve carbon reduction goals, thereby increasing social welfare for residents (Liu et al. 2021; Wang, Wang, Zhang, et al. 2021).To measure the relationship between national economies and CO2 emissions, the concept of carbon intensity, through the Carbon Emissions Index (CEI) is introduced, which generally decreases with technological progress and economic growth. Innovative improvements in production technology can reduce CO2 emissions and enhance the inhibitory effect of technology on CEI increase. The central and western regions of China should learn from the eastern regions to improve interregional cooperation and talent protection mechanisms for lowering CEI. Furthermore, it is important to promote the flow of innovative elements and develop a shared platform for the application of big data to enhance the digitisation of government and businesses. This can be achieved by reducing CO2 emissions through digitalization (Li et al. 2020; Wang, Chen, and Li 2022), digitizing the carbon footprint of individuals and companies and converting it into vegetation coverage can provide a more intuitive participation of the public in carbon reduction actions.

Furthermore, connecting human health interventions with environmental sustainability is crucial, especially considering the severe consequences of water resource waste and land use(Lee et al. 2021), which will reduce the vegetation coverage and weaken the carbon sequestration of plants. While the government has already issued relevant regulations, these regulations primarily target corporate entities and rarely individuals. Therefore, there is still a long way to go in reducing individual carbon footprints. It is thus necessary to analyse carbon footprints for which monitoring and assessment procedures must be developed at both the political and public life levels (Cheng et al. 2020; Mustaffa, Kudus, and Aziz 2022). The government also needs to continuously improve the regulation of the low-carbon consumption market. Additionally, both the national and local government levels should enhance the infrastructure for new energy generation, shoulder their due responsibility for CO2 emission reduction and reduce the import of electricity and coal from the provinces. Moreover, local governments, enterprises and universities need to learn from each other to reduce CO2 emissions, synergistically realise low-carbon development synergistically, and avoid vicious competition(Zhang, Shen, et al. 2022; Xu et al. 2023).

7. Conclusions

CO2 emissions that affect the global ecological environment. Thus, the main goal of government departments and relevant organisations in this regard is to reduce carbon footprints at all levels through reasonable policy guidance. This study used the carbon footprint assessment method to align individual actions with sustainable development, focusing on the individual carbon footprints of clothing, food, housing, and transportation based on personal lifestyle habits. From the analysis of the carbon footprint behaviour and lifestyles of the participating college students, the following conclusions are drawn:

a. The carbon footprints of different campus spatial layouts are heterogenous.
In closed-campus environments, student activities are mostly limited to the campus, resulting in a relatively small proportion of off-campus carbon footprints. In open-campus environments, students have easy access to transportation and there are more recreational facilities nearby, resulting in a relatively large proportion of off-campus carbon footprints (Yan, Zhang, et al. 2022).
b. College students do not yet fully understand and value the concept of low-carbon living
The survey conducted in this study on the understanding, by college students at different year levels, of carbon footprint and their willingness to participate in low-carbon actions revealed that most of them had a vague understanding of the concept of carbon footprint and lacked knowledge about low-carbon living.
c. The proportion of the students' diet in their carbon footprint expenditure was relatively high.
Fast food with its high fat and high protein contents is the primary food of the surveyed students, who thus consumed a large number of disposable chopsticks. Moreover, according to the ranking of campus carbon footprints, water usage had the largest proportion of CO2 emissions, while the choice of transportation and clothing had smaller proportions.
These conclusions further point out the importance of college students' practice of low-carbon life behaviour. Thus, colleges and universities should cultivate a green culture and promote education on an ecological civilization to reduce their CO2 emissions and their relevant institutions and departments should work with college clubs in promoting a green culture, low-carbon awareness and the setting up of a publicity team for the creation of a low-carbon life concept using multiple digital platforms. Moreover, individual students should adopt a reasonable high-protein, low-carbon diet, as opposed to a high-fat and high-protein diet, to reduce their personal carbon footprints as well as to improve their overall health and specifically, to prevent Alzheimer's disease and to delay aging (Rosi et al. 2022).
The carbon footprint calculator shows that evaluating emission methods of CO_2 emission reduction can enhance college students' understanding of how they can help reduce GHG emissions (Wagner et al. 2021).

To further encourage the development of good low-carbon habits among college students, colleges and universities can implement measures such as restricting electricity usage and implementing tiered charges for water and electricity. These measures are important because electricity and water are the main aspects of energy consumption in universities. For example, universities use high-power appliances such as air conditioners. Thus, relevant departments should take measures to intervene in daily high-energy consumption behaviours of student groups, such as cut off power sometimes and standardised electricity usage periods(Almeida, Sousa, and Silva 2021; Kerem 2022).

To further reduce individual carbon footprints, campuses need to strengthen their promotion of low-carbon concepts such as by analysing date related to college students' carbon footprints, working with university clubs and student service centres, and with the school's youth league

committee, to promote the concept of an ecological civilisation and low-carbon environmental protection. At the same time, schools can use social media platforms such as WeChat and Douyin to cultivate a 'frugal and green campus' culture, create a low-carbon campus atmosphere, visualise CO_2 emissions through carbon footprint calculators, cultivate low-carbon environmental protection habits and promote low-carbon travel (Gao et al. 2022; Yan 2022).

Schools should also introduce a curriculum related to ecological ethics education. Climate change, CO_2 emissions, and other concepts impact the life of each individual. Sometimes, the ooffering of low-carbon-related courses in universities can effectively bridge the gap between institutions and the environment (Cordero, Centeno, and Todd 2020; Malan et al. 2020). However, in reality, most universities still focus on traditional ideological and political education, lacking a comprehensive value system that also cultivates students' sense of responsibility for leading a low-carbon way of life. Students generally also have a vague understanding of and lack of interest in new concepts such as carbon footprints. Classroom lectures and textbooks can only create environmental awareness on paper, making it difficult to practically implement energy-saving and CO_2-emission-reduction practices. Therefore, it is necessary for schools to introduce relevant low-carbon environmental courses and establish a related systematic training model while considering the practical CO_2 reduction perspective.

6.1.3. School logistics management reform: 'Universities, as the cradle for nurturing future talents of our country, bear a significant responsibility(Yan, Liu, et al.) CO_2 emissions and low-carbon research' (Xu and Chang 2018,Vol. 10 Issue 5, p63-68). Although the COVID-19 pandemic has limited campus activities for college students and thus has reduced schools' resource consumption, the per capita ecological budget deficit of Hangzhou university students - while slightly lower than the national average - is still significantly higher than the global ecological budget deficit. Therefore, universities need to continuously optimise their campus management models to help achieve the goals of energy conservation, CO_2 emission reduction and the development of a low-carbon circular economy (Cui and Zhang 2022; Ramakrishna and Jose 2022). Campus planning must establish green facilities according to the needs of students, strengthen the maintenance of campus green spaces and promote the sustainable development of an environmental protection campus(Li, Ni, and Dewancker 2019).

Other measures that schools can adopt to create low-carbon campuses are the optimization of their catering logistics management to reduce the use of disposable tableware, the improvement of their energy use through digital reform, and increasing the proportion of their renewable energy consumption(Liu, Shang, and Liu 2023), as well as their adoption of tree planting to control the carbon footprint of students on-campus while increasing the existing biological sequestration of carbon to optimise the low-carbon circular economic model (Yañez, Sinha, and Vásquez 2019). The relevant departments need to regularly carry out green protection and green value activities, further increase the green coverage area of the campus, reasonably distribute seedling species and

ratios, and adopt composite agricultural and forestry techniques to improve the amount of carbon sequestered by green plants, to create a low-carbon campus(Way and Long 2015; Wang, Wang, Qu, et al. 2021). Moreover, the student union and various other organizations could promote a series of environmental activities, such as the "Five Waters Co-governance" initiative, to reduce GHG emissions and CO_2 emissions(Muqeet et al. 2022).

6.1.4. Participation of all people in local government enterprises and private organisations: At the government level, efforts are being made to strengthen the guidance in the development of a low-carbon consumption market and to strike a balance between economic input costs and the benefits of energy conservation as well as CO_2 emission reduction(Yang et al. 2019; Zhang, Hu, et al. 2022). These include establishing a comprehensive CO_2 emissions trading system to regulate the market and compel companies to reduce their CO_2 emissions. When formulating carbon tax policies, the government should add appropriate mechanisms for carbon tax recycling to minimize the impact on related industries and to achieve carbon reduction goals, thereby increasing social welfare for residents (Liu et al. 2021; Wang, Wang, Zhang, et al. 2021).To measure the relationship between national economies and CO_2 emissions, the concept of carbon intensity, through the Carbon Emissions Index (CEI) is introduced, which generally decreases with technological progress and economic growth. Innovative improvements in production technology can reduce CO_2 emissions and enhance the inhibitory effect of technology on CEI increase. The central and western regions of China should learn from the eastern regions to improve interregional cooperation and talent protection mechanisms for lowering CEI. Furthermore, it is important to promote the flow of innovative elements and develop a shared platform for the application of big data to enhance the digitisation of government and businesses. This can be achieved by reducing CO_2 emissions through digitalization (Li et al. 2020; Wang, Chen, and Li 2022), digitizing the carbon footprint of individuals and companies and converting it into vegetation coverage can provide a more intuitive participation of the public in carbon reduction actions.

Furthermore, connecting human health interventions with environmental sustainability is crucial, especially considering the severe consequences of water resource waste and land use(Lee et al. 2021), which will reduce the vegetation coverage and weaken the carbon sequestration of plants. While the government has already issued relevant regulations, these regulations primarily target corporate entities and rarely individuals. Therefore, there is still a long way to go in reducing individual carbon footprints. It is thus necessary to analyse carbon footprints for which monitoring and assessment procedures must be developed at both the political and public life levels (Cheng et al. 2020; Mustaffa, Kudus, and Aziz 2022). The government also needs to continuously improve the regulation of the low-carbon consumption market. Additionally, both the national and local government levels should enhance the infrastructure for new energy generation, shoulder their due responsibility for CO2 emission reduction and reduce the import of electricity and coal from the provinces. Moreover, local governments, enterprises and universities need to learn from each other to reduce CO2 emissions, synergistically realise low-carbon development synergistically, and avoid vicious competition(Zhang, Shen, et al. 2022; Xu et al. 2023).

7. Conclusions

CO2 emissions that affect the global ecological environment. Thus, the main goal of government departments and relevant organisations in this regard is to reduce carbon footprints at all levels through reasonable policy guidance. This study used the carbon footprint assessment method to align individual actions with sustainable development, focusing on the individual carbon footprints of clothing, food, housing, and transportation based on personal lifestyle habits. From the analysis of the carbon footprint behaviour and lifestyles of the participating college students, the following conclusions are drawn:

a. The carbon footprints of different campus spatial layouts are heterogenous.

In closed-campus environments, student activities are mostly limited to the campus, resulting in a relatively small proportion of off-campus carbon footprints. In open-campus environments, students have easy access to transportation and there are more recreational facilities nearby, resulting in a relatively large proportion of off-campus carbon footprints (Yan, Zhang, et al. 2022).

b. College students do not yet fully understand and value the concept of low-carbon living

The survey conducted in this study on the understanding, by college students at different year levels, of carbon footprint and their willingness to participate in low-carbon actions revealed that most of them had a vague understanding of the concept of carbon footprint and lacked knowledge about low-carbon living.

c. The proportion of the students' diet in their carbon footprint expenditure was relatively high.

Fast food with its high fat and high protein contents is the primary food of the surveyed students, who thus consumed a large number of disposable chopsticks. Moreover, according to the ranking of campus carbon footprints, water usage had the largest proportion of CO2 emissions, while the choice of transportation and clothing had smaller proportions.

These conclusions further point out the importance of college students' practice of low-carbon life behaviour. Thus, colleges and universities should cultivate a green culture and promote education on an ecological civilization to reduce their CO2 emissions and their relevant institutions and departments should work with college clubs in promoting a green culture, low-carbon awareness and the setting up of a publicity team for the creation of a low-carbon life concept using multiple digital platforms. Moreover, individual students should adopt a reasonable high-protein, low-carbon diet, as opposed to a high-fat and high-protein diet, to reduce their personal carbon footprints as well as to improve their overall health and specifically, to prevent Alzheimer's disease and to delay aging (Rosi et al. 2022).

Acknowledgements

The authors thank the reviewers for their constructive comments. The present study was supported by a grant from the Medical Science and Technology Project of Zhejiang Province (grant NO. 2018KY351 and 2020KY530), Hangzhou Medical College Institute Special Project (grant NO. YS2021009), Department of Education of Zhejiang Province (grant NO. Y201942573) and Zhejiang Traditional Chinese Medicine Science Administration (grant NO. 2021ZB081),

Hangzhou Medical College Student Development Funding Program (grant NO. FZ080 and FZ096), Hangzhou Medical College's Party Building and Ideological Education Research Program (grant NO. 00004DS202302), National Innovation and Entrepreneurship Training Program for College Students (grant No. 202313023030 and 202313023037X) and Zhejiang Graduate Education Society Programe (grant No. 2023-027 and Y202352216).

Declaration of the authors

The authors declare that they have no conflict of interest regarding the publishing of this paper and that this paper does not include any form of plagiarism.

Appendix

Questionnaire survey on carbon footprint of college students

Question 1: Your gender is [multiple choice questions]

option	subtotal	proportion
man	189	20.72%
woman	723	79.28%
The number of people who fill in this question effectively	**912**	

Question 2: Are you a college student of Hangzhou Medical University? [multiple choice questions]

option	subtotal	proportion
Yes	892	97.81%
actually not	20	2.19%
The number of people who fill in this question effectively	**912**	

Question 3: Your name [fill in the blanks]

Question 4: Your student number [fill in the blanks]

Question 5: Your grade segment is [multiple choice questions]

option	subtotal	proportion
freshman	407	44.63%
Sophomore	364	39.91%
junior	124	13.6%
senior	17	1.86%
Big Five	0	0%
Postgraduate stage	0	0%
The number of people who fill in this question effectively	**912**	

Question 6: What is your understanding of carbon footprint [multiple choice questions]?

option	subtotal	proportion
Understand and pay attention to participating in low-carbon actions.	173	18.97%
Basic understanding but not paying attention to participating in low-carbon actions	393	43.09%
I don't understand but want to participate in low-carbon action.	335	36.73%
Don't understand and don't want to participate in low-carbon actions.	11	1.21%
The number of people who fill in this question effectively	**912**	

Question 7: How many clothes do you buy at least every year [matrix slider]

Line title	average value
Number of clothes	8.99 [Details]
	Subtotal: 8.99 Average: 8.99

Question 8: How many bowls of rice do you eat every day [matrix slider]

Line title	average value
Bowls of rice	2.18 [Details]
	Subtotal: 2.18 Average: 2.18

Question 9: How many eggs do you eat in a week [matrix slider]

Line title	average value
Number of eggs	4.46 [Details]
	Subtotal: 4.46 Average: 4.46

Question 10: How much milk do you take in a week (bag) [matrix slider]

Line title	average value
Milk quantity (bag)	4.14 [Details]
	Subtotal: 4.14 Average: 4.14

Question 11: How many times do you eat meat food a week [matrix slider]

Line title	average value
Meat food frequency	9.66 [Details]
	Subtotal: 9.66 Average: 9.66

Question 12: When you order takeout, do you use disposable chopsticks [matrix multiple choice questions]

Title \ Options	always	often	common	once in a while	precious few
frequency of utilization	261(28.62%)	312(34.21%)	165(18.09%)	109(11.95%)	65(7.13%)

Question 13: How often do you order takeout every week [matrix slider]

Line title	average value
Takeaway frequency	4.21 [Details]
	Subtotal: 4.21 Average: 4.21

Question 14: How many plastic bags (including take-away packaging) do you usually use one day [matrix slider]

Line title	average value
Number of plastic bags (including takeaway packaging)	2.88 [Details]

Question 15: How often do you use facial tissues [matrix slider]

Line title	average value
Frequency of facial tissues (a pack every few days)	6.93 [Details]
	Subtotal: 6.93 Average: 6.93

Question 16: How many times do you bathe per week [matrix slider]

Line title	average value
Bathing times	5.7 [Details]
	Subtotal: 5.7 Average: 5.7

Question 17: Time required for each bath [matrix slider]

Line title	average value
Bath time (minutes)	15.86 [Details]
	Subtotal: 15.86 Average: 15.86

Question 18: Which way do you often travel [multiple choice questions]

option	subtotal	proportion
bus	656	71.93%
subway	665	72.92%
taxi	452	49.56%
bike-sharing	386	42.32%
Other [detailed]	122	13.38%
The number of people who fill in this question effectively	**912**	

Question 19: The distance between your destinations is generally in [matrix slider].

Line title	average value
Destination distance (km)	5.56 [Details]
	Subtotal: 5.56 Average: 5.56

Question 20: How often do you use travel tools [matrix slider]

Line title	average value
Frequency of use (once every few days)	6.51 [Details]
	Subtotal: 6.51 Average: 6.51

Question 21: If a low-carbon life helps to protect the environment, will you choose a low-carbon life [multiple choice questions]?

option	subtotal	proportion
can	908	99.56%
can't	4	0.44%
The number of people who fill in this question effectively	912	

Question 22: If there were environmental protection actions such as planting trees, would you choose to participate in them at the first time [multiple choice questions]

option	subtotal	proportion
can	883	96.82%
can't	29	3.18%
The number of people who fill in this question effectively	912	

References

1. Almeida AP., Sousa V., Silva CM., 2021. 'Methodology for estimating energy and water consumption patterns in university buildings: case study, Federal University of Roraima (UFRR)'. Heliyon 7: e08642.
2. Cederberg C., Persson UM., Schmidt S., Hedenus F., Wood R., 2019. Beyond the borders–burdens of Swedish food consumption due to agrochemicals, greenhouse gases and land-use change. Journal of Cleaner Production 214: 644-52
3. Chen W., Li J., 2019. 'Who are the low-carbon activists? Analysis of the influence mechanism and group characteristics of low-carbon behavior in Tianjin, China'. Science of the Total Environment 683: 729-36
4. Cheng S., Fan W., Meng F., Chen J., Cai B., Liu G., Liang S., Song M., Zhou Y., Yang Z., 2020. 'Toward low-carbon development: Assessing emissions-reduction pressure among Chinese cities, J Environ Manage 271: 111036.
5. Cordero EC., Centeno D., Todd AM., 2020. The role of climate change education on individual lifetime carbon emissions. PLoS One, 15: e0206266.
6. Cui T., Zhang Y., 2022. Research on the impact of circular economy on total factor carbon productivity in China. Environ Sci Pollut Res Int 29: 78780-94.
7. Fernández M., Cebrián G., Regadera E., Fernández MY., 2020. Analysing the Relationship between University Students' Ecological Footprint and Their Connection with Nature and Pro-Environmental Attitude. International Journal of Environmental Research and Public Health 17: 8826.
8. Christopher FB., Barros VR., 2014. Climate change 2014–Impacts, adaptation and vulnerability: Regional aspects (Cambridge University Press).
9. Filho WL., Vidal DG., Dinis MAP., Lambrechts W., Vasconcelos CRP., Molthan-Hill P., Abubakar IR., Dunk RM., Salvia AL., 2023. Low carbon futures: assessing the status of decarbonisation efforts at universities within a 2050 perspective. Energy Sustain Soc 13: 5.
10. Filimonau V., Archer D., Bellamy L., Smith N., Wintrip R., 2021. The carbon footprint of a UK University during the COVID-19 lockdown. Sci Total Environ 756: 143964.

11. Filimonau V., Archer D., Bellamy L., Smith N., Wintrip R., 2021b. The carbon footprint of a UK University during the COVID-19 lockdown Science of The Total Environment, 756: 143964.
12. Gao P., Zhong L., Han B., He M., Sun Y., 2022. Green Carbon Science: Keeping the Pace in Practice. Angew Chem Int Ed Engl 61: e202210095.
13. Geng Y., Zhu R., Maimaituerxun M., 2022. Bibliometric review of carbon neutrality with CiteSpace: evolution, trends, and framework. Environ Sci Pollut Res Int 29: 76668-76686.
14. González-García S, Esteve-Llorens X., Moreira MT., Feijoo G., 2018. Carbon footprint and nutritional quality of different human dietary choices. Science of The Total Environment 644: 77-94.
15. Kerem A., 2022. Assessing the electricity energy efficiency of university campus exterior lighting system and proposing energy-saving strategies for carbon emission reduction. Microsyst Technol 28: 2623-2640.
16. Lee KM., Dias G., Boluk K., Scott S., Chang Y., Williams TE., Kirkpatrick S., 2021. Toward a healthy and environmentally sustainable campus food environment: a scoping review of postsecondary food interventions. Advances in Nutrition 12: 1996-2022.
17. Li D., Lei Y., Li L., Liu L., 2020. Study on industrial selection of counterpart cooperation between Jilin province and Zhejiang province in China from the perspective of low carbon. Environmental Science and Pollution Research 27: 16668-16676.
18. Ruishi L., Zhao R., Xie Z., Xiao L., Chuai X., Feng M., Zhang H., Luo H., 2022. Water–energy–carbon nexus at campus scale: Case of North China University of Water Resources and Electric Power. Energy Policy 166: 113001.
19. Xinqin L., Ni G., Dewancker B., 2019. Improving the attractiveness and accessibility of campus green space for developing a sustainable university environment. Environmental Science and Pollution Research 26: 33399-33415.
20. Boqiang L., Yang M., 2022. Does knowledge really help?: the relationship between low-carbon knowledge and low-carbon behavior. Journal of Global Information Management (JGIM) 30: 1-22.
21. Liu C., Shang J., Liu C., 2023. Exploring Household Food Waste Reduction for Carbon Footprint Mitigation: A Case Study in Shanghai, China. Foods 12: 3211.
22. Weijiang L., Li Y., Liu T., Liu M., Wei H., 2021. How to promote low-carbon economic development? A comprehensive assessment of carbon tax policy in China. International journal of environmental research and public health 18: 10699.
23. Lizana J., Manteigas V., Chacartegui R., Lage J., Becerra JA., Blondeau P., Rato R., Silva F., Gamarra AR., Herrera I., Gomes M., Fernandez A., Berthier C., Gonçalves K., Alexandre JL., Almeida-Silva M., Almeida SM., 2021. A methodology to empower citizens towards a low-carbon economy. The potential of schools and sustainability indicators. J Environ Manage 284: 112043.
24. Hannah M., Challamel GA., Silverstein D., Hoffs C., Spang E., Pace SA., Malagueño BLR., Gardner CD., Wang MC., Slusser W., Jay JA., 2020. Impact of a Scalable, Multi-Campus "Foodprint" Seminar on College Students' Dietary Intake and Dietary Carbon Footprint. Nutrients

12: 2890.
25. Abdul MH., Javed H., Akhter MN., Shahzad M., Munir HM., Nadeem MU., Bukhari SSH., Huba M., 2022. Sustainable solutions for advanced energy management system of campus microgrids: Model opportunities and future challenges. Sensors 22: 2345.
26. Mustaffa NK., Kudus SA., Aziz MFHA., 2022. Key drivers, challenges and strategies towards successful low-carbon campus: the case of UiTM Shah Alam campus. Journal of Facilities Management.
27. Ramakrishna S., Jose R., 2022. Addressing sustainability gaps. Sci Total Environ 806: 151208.
28. Rosi A., Biasini B., Monica E., Rapetti V., Deon V., Scazzina F., 2022. Nutritional Composition and Environmental Impact of Meals Selected in Workplace Canteens before and after an Intervention Promoting the Adherence to the Mediterranean Diet. Nutrients 14: 4456.
29. Oliver W., Tholen L., Nawothnig L., Albert-Seifried S., 2021. Making School-Based GHG-Emissions Tangible by Student-Led Carbon Footprint Assessment Program. Energies 14: 8858.
30. Wang L., Zhu L., Pan S., Wang S., 2023. Low-carbon emitting university campus achieved via anaerobic digestion of canteen food wastes. J Environ Manage 335: 117533.
31. Lulu W., Chen L., Li Y., 2022. Digital economy and urban low-carbon sustainable development: The role of innovation factor mobility in China. Environmental Science and Pollution Research 29: 48539-48557
32. Wang W., Wang Y., Zhang X., Zhang D., 2021. Effects of Government Subsidies on Production and Emissions Reduction Decisions under Carbon Tax Regulation and Consumer Low-Carbon Awareness. Int J Environ Res Public Health 18: 10959.
33. Xueyan W., Wang Y., Qu X., Huang B., Li Z., Sun J., Wei X., Yang X., 2021. Urban trees in university campus: structure, function, and ecological values. Environmental Science and Pollution Research 28: 45183-45198.
34. Way DA., Long SP., 2015. Climate-smart agriculture and forestry: maintaining plant productivity in a changing world while minimizing production system effects on climate. Plant Cell Environ 38: 1683-1685.
35. Xu Y., Ge W., Liu G., Su X., Zhu J., Yang C., Yang X., Ran Q., 2023. The impact of local government competition and green technology innovation on economic low-carbon transition: new insights from China. Environ Sci Pollut Res Int 30: 23714-23735.
36. Zhao X., Chang G., 2018. Low-Carbon Campus Construction Based on Ecological Footprint Theory: A Case Study of Shenzhen Graduate School, Peking University. Journal of Landscape Research.
37. Yan B., Liu L., Zhao L., Hinz U., Luo Y., An X., Gladkich J., de la Torre C., Huang Z., Schrapel D., Gross W., Fortunato F., Schaefer M., Gaida MM., Herr I., 2022. Tumor and stroma COL8A1 secretion induces autocrine and paracrine progression signaling in pancreatic ductal adenocarcinoma. Matrix Biol 114: 84-107.
38. Yan J., Zhang Z., Chen M., Lin T., Yuan K., 2022. How will Chinese cities reduce their

carbon emissions? Evidence from spatial differences. Environ Sci Pollut Res Int 29: 72461-72479.
39. Yan N., 2022. Legal Guarantee of Smart City Pilot and Green and Low-Carbon Development. J Environ Public Health 2022: 4280441.
40. Pablo Y., Sinha A., Vásquez M., 2019. Carbon footprint estimation in a university campus: Evaluation and insights. Sustainability 12: 181.
41. Yang W., Zhao R., Chuai X., Xiao L., Cao L., Zhang Z., Yang Q., Yao L., 2019. China's pathway to a low carbon economy. Carbon Balance Manag 14: 14.
42. Yin Z., Jiang X., Lin S., Liu J., 2022. The impact of online education on carbon emissions in the context of the COVID-19 pandemic - Taking Chinese universities as examples. Appl Energy, 314: 118875.
43. Zhang X., Shen M., Luan Y., Cui W., Lin X., 2022. Spatial Evolutionary Characteristics and Influencing Factors of Urban Industrial Carbon Emission in China. Int J Environ Res Public Health. 19: 11227.
44. Zhang Z., Hu G., Mu X., Kong L., 2022. From low carbon to carbon neutrality: A bibliometric analysis of the status, evolution and development trend. J Environ Manage 322: 116087.
45. Rui Z., Yang M., Liu J., Yang L., Bao Z., Ren X., 2020. University Students' Purchase Intention and Willingness to Pay for Carbon-Labeled Food Products: A Purchase Decision-Making Experiment. International Journal of Environmental Research and Public Health 17: 7026.
Niting Z., Li S., Wang Y., Huang Y., Bartoccid P., Fantozzid F., Huang J., Xing L., Yang H., Chen H., Yang Q., Li J., 2021. Research on low-carbon campus based on ecological footprint evaluation and machine learning: A case study in China. Journal of Cleaner Production 323: 129181.