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Application of ecological footprint in the construction of ecological campus

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Abstract. In order to help Shandong University of Science and Technology with the construction of Eco-campus, a study on the ecological status of the campus has been carried out. With the help of the component method of ecological footprint, the ecological footprint and efficiency of Shandong University of Science and Technology in 2016 has been analyzed well. The results showed that the ecological footprint of Shandong University of Science and Technology was 18058.46hm^2 in total, and that the ecological efficiency was 2.22 person·hm^{-2}. The footprint of energy consumption, accounting for 46.2% of the total footprint, is the largest, followed by food consumption and garbage. The construction of Eco-campus should focus on the above-mentioned three aspects. Compared with other colleges and universities at home and abroad, the ecological carrying capacity of Shandong University of Science and Technology was higher while the ecological efficiency was much lower. Obviously, its construction of Eco-campus was lagged behind those first-class universities. The study showed that policy support and economic input would have an important impact on ecological construction of colleges and universities. According to the characteristics of the ecological footprint structure, this paper puts forward some reasonable suggestions from two aspects: campus ecological construction and “personnel training”, and provides reference for the construction of Eco-campus in colleges and universities.

1. Introduction

Climate change is a common concern in the world today, and low-carbon, energy-saving and emission reduction are regarded as the main ways of life all the time. Many domestic universities have responded to the proposal to build low-carbon campus. Sustainable development with low-carbon campus construction as the main content has become a trend to build a green campus [1]. Green campus based on ecological footprint is an effective method to measure the sustainable development of campus. At present, the study of campus ecological footprint in our country follows the international common method.

Many domestic scholars have measured and calculated the University ecological footprint, analyzed the profit and loss and proposed the corresponding countermeasure [2-6]. In the study of green campus environment assessment system based on ecological footprint method, Zhou Tianhan has found out the potential problems in the environmental evaluation of the ecological footprint and constructed the green campus evaluation system based on ecological footprint method by summarizing the existing green campus environment evaluation system[7-9]; Gu Xiaowei has adopted the ecological footprint analysis method including comprehensive and component method to evaluated the level of the green ecological campus of Northeastern University so as to conclude the general structure

of the University of ecological footprint, and she has put forward the standard of measuring ecological efficiency in universities in the first time[10-11]; Yao Zheng has measured and calculated the ecological footprint of Peking University ranging from transportation, energy to daily life and drawn a conclusion that the ecological footprint of energy was a little higher while transportation and daily life were much lower when compared with other universities, and he has also called for the Low Carbon Campus[12]; Fu Yanfang has calculated the ecological footprint of Chizhou college by adopting the component method, evaluated the ecological footprint and ecological efficiency of resource consumption in Chizhou college, and pointed out more detailed conclusions and suggestion[13]s; L.M. Nunes has proposed firstly the high uncertainty of ecological footprint and the great potential effects of the sensitive parameters on the calculated value in the basis of the analysis of uncertainty and variability of model parameter in order to provide the comparison of ecological footprint among universities a powerful framework and make the ecological footprint method more complete[14].

Shandong University of Science and Technology is a large-scale undergraduate institution in Shandong province. It covers an area of 243hm^2 and has more than 40,000 students. At present, there are few reports about the ecological footprint measurement in this school even in Shandong province. In view of this fact, we puts forward the ecological footprint component and ecological efficiency of Shandong University of Science and Technology by constructing the ecological footprint model of campus, quantitatively analyzes the ecological structure of Shandong University of Science and Technology, and offer the rational suggestion of ecological campus construction of Shandong University of Science and Technology by relating to the construction concept of low-carbon campus. In addition, this model is used to analyze the “ecological construction” [15] of campus operation, educational purpose and policy formulation, which provides a comprehensive reference for the ecological construction of universities.

2. Summary of Ecological Footprint

2.1. Ecological Footprint and Ecological Efficiency

The ecological footprint of a region refers to the productive area of land needed to produce all the resources consumed by these people and to absorb all the wastes produced by these people [16]. The global productive land is divided into 6 types: fossil energy land, arable land, forest land, pasture land, built area and water area. The ecological footprint is finally expressed as the land area with the average level of global biological productivity. First, count the ecological footprint consumption and ecological footprint supply respectively through the establishment of ecological accounts; second, judge the regional sustainable development by comparing the two; finally, obtain the total area of land occupation, in which global hectare as a measuring unit, that is, the ecological footprint, by using the equal factor of various kinds of land multiplies by the occupied area of the corresponding type of land. However, for those small range of research objects (such as schools and individuals), it is right to add up the 6 types of land area without any converting.

There are two methods to calculate the ecological footprint: comprehensive method and component method. The comprehensive method is based on the macroscopic statistics of all kinds of substances, aims to count the overall consumption of the various regions or groups and their corresponding ecological footprint, applies to the global, national and regional level of large-scale ecological footprint research, while the component method calculates the material consumption and ecological footprint of the study object on the basis of the monomer measurement that constitutes the consumption component and applies to small objects, such as towns, villages, schools, companies, individuals or individual activities etc..Therefore, this paper will adopt the component method to calculate the ecological footprint, transferring the school's energy, food, garbage, transportation, paper, water resources and other annual consumption into six types of global bio-productive land, then adding together and drawing the campus ecology Resources.

For universities, the output of ecological resources is students. The number of students in the unit ecological footprint can be defined as the ecological efficiency. It quantitatively describes the amount of talents that can be supported by the unit ecological resources. At the same time, the amount of

ecological resources that universities need to consume for training unit personnel can be defined as the ecological consumption intensity.

2.2. Ecological Footprint Component Model

2.2.1. Calculation of ecological footprint. Where: A is the area of an ecological footprint required by a particular part of the year; Q represents the annual consumption of this component; P is the average annual yield or carrying capacity of ecological land; for some specific land, when they are converted, it is necessary to refine the formula, such as the calculation of energy consumption in the year and a variety of types of energy to a final standard, which needs to determine the different Equivalent coefficient and deduce the formula.

$$A = Q / P \tag{1}$$

2.2.2. The establishment of various ecological land models

1) The ecological footprint of energy

The main energy resources are coal, petroleum, gas and electricity. The impact of energy consumption on the ecological environment is mainly manifested by the greenhouse effect caused by CO_2 emission; there needs to be enough woodland to absorb CO_2 in order to offset the impact, so the occupied land of energy consumption is woodland. Because this kind of land is devoted to absorb CO_2, not take the purpose for producing forest products, it belongs to the independent list, known as the "fossil fuels". The 4 kinds of energy consumption mentioned above require fossil energy land area:

$$A_c = Q_c \eta C_c \beta / P_a \tag{2}$$

$$A_o = Q_o O_c \beta / P \tag{3}$$

$$A_g = Q_g \rho G_c \beta / P_a \tag{4}$$

$$A_e = Q_e E_{CO_2} / P \tag{5}$$

Where: A_c, A_o, A_g, and A_e are the areas of fossil energy land of coal, oil, gas and electricity consumption during the year respectively; Q_c, Q_o, Q_g and Q_e are the consumption of coal, oil, gas and electricity during the year respectively; η is the average coal-fired boiler combustion rate; C_c, O_c, G_c and E_c are the C emission factors of coal, oil and gas respectively; β is the transforming factor for C to CO_2; ρ is the density of gas; E_{CO_2} is the CO_2 emission per unit generating capacity of an ordinary thermal power plant; P_a is the average amount of absorbed CO_2 per hectare of forest land per year (i.e., the average productivity of fossil energy sources).

2) The ecological footprint of food

The general formula for the land occupation of a particular kind of food consumption is:

$$A_f = Q_f / P_f \tag{6}$$

Where: A_f is the land occupation area for a certain category of food consumption in a year; Q_f is the the amount of the consumption of this food in the year; P_f is the average productivity of the land for the production of such food. In the main food categories, the land occupied by cattle and sheep (milk) products is grassland; the land for pigs, poultry, eggs, grains, sugar and vegetables, etc. is cultivated; the land for fish is water.

3) The ecological footprint of garbage

The occupied land of garbage usually consists of two parts: the fossil energy land, indirect occupied land, which is used to absorb CO_2 of the degradation of waste, and the land that is directly occupied by the rubbish (usually cultivated land). The waste in the rubbish dump produces so-called waste gas through the action of bacteria. The volume of the waste gas is about half of CO_2 and half of CH4 [18]. Global warming is not only related to CO_2, but also related to CH_4 [19-20]. The amount of

CH_4 can be converted into global warming latent heat GWP which is equivalent to greenhouse effect, that is to say, the CO_2 amount of which produces the same greenhouse effect [21]. The indirect occupied land for calculating garbage should be calculated separately according to the composition of the garbage:

$$A_w = \frac{1}{P_a}\sum_{i=1}^{N_w} Q_i\left(q_i^{CO_2} + q_i^{CH_4}\chi\right) \tag{7}$$

Where: A_w is the indirect land occupation area for annual garbage discharge; Q_i is the the emission of the ith waste components during the year; $q_i^{CO_2}$ is the CO_2 production rate of the ith waste components; $q_i^{CH_4}$ is the CH_4 production rate for the ith waste components; χ is the GWP equivalent coefficient of CH_4; P_a is identical to (2).

4) The ecological footprint of traffic

The ecological footprint of traffic consists of direct land occupation and indirect land occupation. The direct occupation of land including roads, stations, airports, parking lot. Due to the mobility of vehicles and the sharing of traffic facilities such as roads, the calculation of the direct land occupation is a little complex and needs to share the area of the relevant facilities with the study object according to traffic regional ownership and utilization degree, transportation quantity and mileage statistics. Indirect land occupation refers to the fossil energy required for the absorption of greenhouse gas emissions from various modes of transportation. The main greenhouse gases in the exhausting gas are CO_2, CH_4 and N_20, etc. CH_4 and N_2O can be converted to CO_2 equivalent according to their GWP. The general formula for land is:

$$A_t = \frac{D}{P_a}\sum_{i=1}^{n} q_i\chi_i \tag{8}$$

Where: A_t is the area of indirect land occupation of a certain type of vehicle during the year; D is the mileage of this kind of vehicle during the year; q_i is the emission of the ith greenhouse gas per unit of mileage; χ_i is the GWP equivalent coefficient of the ith greenhouse gas; P_a equation (2).

5) The ecological footprint of paper

The area of paper consumption is mainly woodland, and the formula is:

$$A_P = Q_P q_w / p_w \tag{9}$$

Where: A_p is the land occupation area of paper consumption in the year; Q_p is the paper consumption during the year; Q_w is the timber consumption of per unit paper; P_w is the average timber productivity of forest land.

6) The ecological footprint of water

The ecological footprint of water is mainly generated by the energy produced by the transportation of water and the treatment of the sewage, and the energy consumed by the two operations is electricity, so it is necessary to calculate the power consumption of the water and the sewage for the year firstly, and then use the formula (5) calculate the land occupied area. The land type is fossil energy.

3. Ecological Footprint Calculation of Shandong University of Science and Technology in 2016

In the calculation of the ecological footprint of Shandong University of Science and Technology, energy (mainly electricity), food, garbage, paper, water and traffic have been taken into account. Electricity and water data are from the school energy management section; food data comes from the school logistics diet center; the vehicle data are provided by the Shandong University of Science and Technology security service; the amount of rubbish is estimated by sampling; a portion of the paper is provided by the school office, and part of it is obtained from a personal survey. The data collection and survey covers the teaching area and student living quarters of the campus, excluding family residential areas (except for vehicle surveys). The related factors, emission parameters and equivalent coefficients in the calculation were obtained from the IPCC Guidelines for National Greenhouse Gas

Inventories(2006)[22]and relevant reports of the World Conservation Fund; the world's average productivity of land is taken from FAO Statistics (http://www,.Fao.org).

Table 1. Ecological footprint of energy sources in Shandong University of Science and Technology (SDUST) in 2016(The density of gas is 0.75 * 10^{-3}t/m^3)

component	Consumption	Cemission factor	C-CO_2 Transforming factor	Unit CO_2 emission	P_a/(t·hm^{-2})	Footprint /hm^2	Land type
gas [1)] /10^3m^3	780	0.409	3.67	1.12	5.2	168.9	Fossil energy sites
Power /GWh	12.82			1054	5.2	2598.5	Fossil energy sites
Thermal energy /GWh	27.53			1054	5.2	5580.1	Fossil energy site
Total						8347.5	

3.1. The Ecological Footprint of Energy

In the campus of Shandong University of Science and Technology, The main energy consumption for electricity and heat, specifically, the electricity includes lighting and living electricity, the teaching building and student apartments in the winter heating facilities for heating. In addition, the school cafeteria also uses gas for energy. According to the data provided by the water and electricity warming Office of Shandong University of Science and Technology, the ecological footprint of energy of Shandong University of Science and Technology in 2016 was calculated. The relevant calculation data and results are shown in table 1.

3.2. The Ecological Footprint of the Food

The ecological footprint of the research includes the total amount of food consumed by the Shandong University of Science and Technology, including the cafeteria purchase, supermarket, apartment building service department of food purchases, the outside supermarket and the amount of buying food negligible. By calculating the total consumption of six categories of grain, meat, eggs, milk, fruit and vegetables and the global average amount of them, you can get the ecological footprint of food in Shandong University of Science and Technology in 2016. The relevant data and results of the calculation of food ecological footprint are shown in table 2.

Table 2. Ecological footprint of food in SDUST in 2016

component	World average production capacity /(kg.hm-2)	Consumption /kg	Ecological footprint /hm2	Land type
Pork	74	156434	2113.97	Cultivated land
Beef and mutton	33	4221	127.91	Grassland
fish	44	95753	2176.20	waters
chicken	200	223000	1115	Cultivated land
foodstuff	3077	968434	314.73	Cultivated land
Fruits	9562	7032	0.74	Cultivated land
Sugar	18000	5725	0.32	Cultivated land
Vegetables	16846	1264219	75.05	Cultivated land
Eggs	400	260707	651.77	Cultivated land
Peas and beans	1856	128312	69.13	Cultivated land
milk	502	10524	20.96	Grassland
Total			6665.8	

3.3. The Ecological Footprint of Rubbish

According to the survey, there is a large gap between the number of daily garbage production in Shandong University of Science and Technology campus; the general amount of garbage on weekends is obviously more than working days, and the amount of garbage in graduation season, before and after winter and summer vacation is more than the general time. In addition, food waste needs orientation treatment and is distinguished with non-food waste. According to the statistics, the average daily non-food waste production is 10t in the general working days while the average daily garbage generation is 15t on weekends. The garbage production of special periods (before and after the holiday or graduation season) is 25t. However, the special periods exist as a minority, so it can be calculated in accordance with the amount of garbage on weekends. Within one year (excluding 84 days off) the proportion of working days and holidays within one year is about 5: 2, resulting in the total amount of non-food waste for the year is 3223.2t. The annual output of food waste is 1539t. Because the direct land occupation of garbage is small and lacks detailed data, it is neglected in the calculation of this paper. The relevant data and calculation results of indirect land use are shown in figure 1. The calculated garbage ecological footprint data are shown in table 3.

Table 3. Ecological footprint of garbage and paper in SDUST in 2016

component	Emission amount	CO_2 release amount per unit garbage /t	CH_4 release rate per unit waste	The GWP coefficient of CH_4[23]	GWP equivalent CH_4/t	Total amount of CO_2 in unit garbage /t	Pa/(t·hm^{-2})	Ecological footprint /hm^2	Land type
textile	1050	0.1524	0.0554	25	1.2742	1.5374	5.2	310.4	Fossil energy sites
Plastic[24]	673.2					6	5.2	776.8	Fossil energy sites
Park garbage	1500	0.0649	0.0236	25	0.5428	0.6549	5.2	188.9	Fossil energy sites
Food waste	1539	0.051	0.0208	25	0.4784	0.5551	5.2	163.1	Fossil energy sites
Glass	40.85					9.88	5.2	77.6	Fossil energy sites
Total								1516.8	

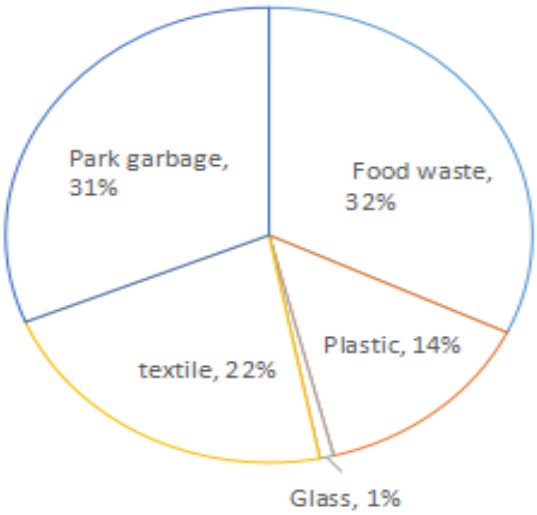

Figure 1. Comtnnents of SDUST's waste

3.4. The Ecological Footprint of Paper and Water

By giving away questionnaires (1500 copies) to teachers and students of various majors of different colleges in Shandong University of Science and Technology in order to obtain the consumption of of paper (read and print), clothes and non-environmental products (plastic bags and disposable chopsticks), due to the relatively dispersing investigated objects, the data of the questionnaires can be taken for a reference in terms of the calculations of the whole teachers and students of the campus. The data shows that at Shandong University of Science and Technology, the amount of consumer paper is 350.4t in 2016, of which personal paper 312t, accounting for 89%, and office paper 38.4t, and accounting for 11%. Per ton of paper requires 4m^3 wood, and a total of 1401.6m^3 wood is needed. The world timber productivity of forest land is 1.99m^3. It was concluded that the ecological footprint of paper in Shandong University of Science and Technology was 704.32 hm^2 in 2016 and tap water consumption was 1,540,000m^3. During the same period, the price of the tap water in Qingdao was 3.55 yuan /m^3 (including sewage treatment), and the industrial electricity price was 0.5014 yuan / (kW • h). The power costs of tap water accounted for 1/4, converted to power consumption of about 1.8 kW • h/ m^3. Therefore, the total electricity consumption of water supply is 2.78GW·h, and the corresponding CO_2 emission is 2930t, divided by the average absorption capacity of CO_2 (5.2t/hm^2), and the ecological footprint of water supply is 563.5hm^2. Because of the lack of data, the ecological footprint of sewage treatment has not been calculated.

3.5. The Ecological Footprint of Traffic

The vehicles of the campus of Shandong University of Science and Technology are mainly the cars of the staffs. According to the survey, the number of registered vehicles on campus is 2992. And the number of unregistered temporary vehicles can be found by the security department record. In addition, a small number of students use electric cars and motorcycles. Private cars, temporary cars and motorcycles consume gasoline while those trucks which are used to transport the waste such as food waste and campus waste use diesel fuel. Because the displacement of CH_4 and N_2O is small and detailed data is difficult to obtain, only CO_2 is considered. The relevant data and results of the calculation of traffic ecological footprint are shown in table 4.

Table 4. Ecological footprint of traffic in SDUST in 2016

Component	Annual mileage	CO2 release	Pa/(t·hm^{-2})	Ecological footprint /hm2	Land type
Gasoline car	438147	0.205	5.2	17.3	Fossil energy sites
Diesel engined car	1730	0.72	5.2	0.24	Fossil energy sites
Total				17.54	

4. Comparative Analysis of Ecological Footprint between Shandong University of Science and Technology and Other Universities

4.1. Shandong University of Science and Technology Ecological Footprint of Each Component

The results of each component's footprint are summarized in table5. In 2016, the total footprint of Shandong University of Science and Technology university is about 18,058.46 hm^2, that is to say, 18,058.46hm^2 of various types of land are required to support the consumption in Shandong University of Science and Technology teaching and students' living area as well as absorb the waste. It should be noted that the calculation of food footprint is lower than the actual value, because some food consumption occurs outside of the campus and there is no statistics; The garbage footprint is also lower than the actual value due to not calculates the direct occupancy area. Therefore, the results of this paper should be a conservative estimate of the actual ecological footprint.

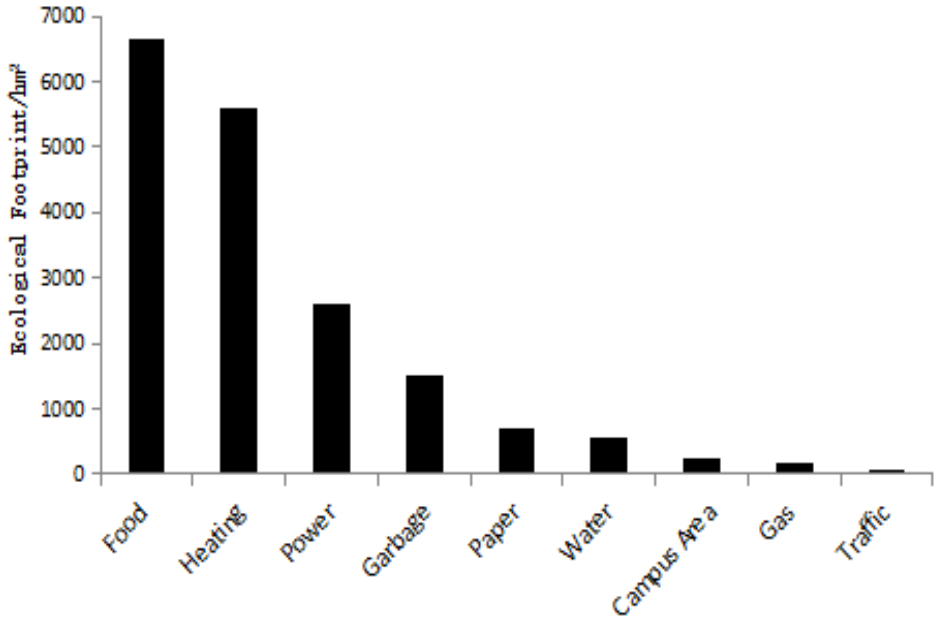

Figure 2. Ecological footprint of different components of SDUST 2016

In 2016, Shandong University of Science and Technology had more than 40,000 students (take 40,000 as the standard), thus the ecological efficiency is 2.22 preson· hm^{-2} and the ecological consumption intensity is 0.45hm^2/ person. The comparison among the ecological footprint of various components is shown in Figure 2, and the main components of the ecological footprints of Shandong University of Science and Technology are food, heat, electricity and garbage, respectively 36.9%、30.9%、14.4% and 8.4%, totally 90.6%. Therefore, to reduce the ecological efficiency and increase the average ecological footprint should be discussed from the four aspects. Improving energy structure and taking effective measures to save energy and reducing waste discharge are the main way to

improve eco-efficiency of Shandong University of Science and Technology and build the green campus.

Based on the ecological footprint of Shandong University of Science and Technology, this paper analyzes the ecological structure of the campus and draws the focus of ecological campus construction. In order to gain a deeper understanding of the current situation of the ecological components of the campus and draw a more comprehensive conclusion, the paper obtains the characteristics of the ecological structure of Shandong University of Science and Technology so as to put forward reasonable proposals in the point of ecological construction by comparing with the ecological components of the universities at home and abroad.

Table 5. Total Ecological footprint of SDUST 2016

Project		Shandong University of Science and Technology	
		Ecological Footprint	Proportion
Energy		8347.5	46.2
	Heating	5580.1	30.9
	Power	2598.5	14.4
	Gas	168.9	0.9
daily life		8886.92	49.2
	Food	6665.8	36.9
	Garbage	1516.8	8.4
	Paper	704.32	3.9
Water		563.5	3.1
Traffic		17.54	0.1
Campus Area		243	1.4
Total		18058.46	100

4.2. Comparison with Foreign Universities

Table 6 is mainly reference data of ecological footprint of other foreign universities. The scale of these universities (where the scale of a school is the number of school people and the school area ratio) is similar with Shandong University of Science and Technology, except the differences of different indicators. As a result, the ecological footprint of Shandong University of Science and Technology has the following characteristics:

Table 6. SDUST eco-footprint compared with overseas universities

Project		Chicago USA [25] University of Illinois		Australia [26] University of Newcastle		Canada[27] Kwantlen University		China Shandong University of Science and Technology	
		Ecological Footprint	Proportion	Ecological Footprint	Proportion	Ecological Footprint	Proportion	Ecological Footprint	Proportion
Energy		70955.9	72.7	1688.2	47.0	878.3	28.9	8347.5	46.9
	Heating	-	-	-	-	-	-	5580.1	31.3
	Power	70955.9	72.7	1257.2	35.0	878.3	28.9	2598.5	14.6
	Natural gas	-	-	431	12.0	-	-	168.9	0.9
Daily life		15054.5	14.4	143.6	4.0	510.6	16.8	8440.12	47.4
	Food	2537.6	2.6	71.8	2.0	291.7	9.6	6665.8	37.4
	Garbage	12516.9	11.8	71.8	2.0	-	-	1516.8	8.5
	Paper	-	-	-	-	218.9	7.2	704.32	4.0
Water		126.9	0.13	35.9	1.0	6.1	0.2	563.5	3.2
Traffic		1356.7	1.39	1652.3	46.0	1610.7	53	17.54	0.1
Total		97601	100	3592	100	3039	100	17815.46	100

(1) For similar-scale school, in the ecological footprint of Shandong University of Science and Technology, the daily consumption is more than half, far more than other foreign universities; The ecological footprint of traffic is as much as ten times as high as that of other universities. It should be noted that the listed colleges and universities are all from developed countries, which differ from our country in the economic and political aspects, while Shandong University of Science and Technology belongs to a general undergraduate university. Therefore, comparing with the listed universities, the comprehensive level of the school is lower. Because of insufficient data collection, universities in developing countries with the same scale of schooling have not been listed.

(2) Comparing with the energy structure of other universities, Shandong University of Science and Technology's energy use is of diversity, but all these energy belong to clean energy and the consumption of fossil coal, oil and gas is very low even to 0. Therefore, from the point of the ecological structure, the ecological structure of Shandong University of Science and Technology energy is relatively healthy.

4.3. Compared with Domestic Universities

(1) From the total amount of the ecological footprint, Shandong University of Science and Technology is at a middle level in domestic universities. Compared with the first-class universities of the same scale, the total ecological footprint of Shandong University of Science and Technology is lower; compared with ordinary universities, the total ecological footprint is ahead.

Table 7. SDUST eco-footprint compared with home universities

colleges and universities		Ecological footprint summary								Quant-ity	Av-erage	Refer-ences
		Energy	Food	Garb-age	Pap-er	Wa-ter	Traffi-c	Cam-pus Area	Total			
First-class Univ-ersity	Peking University	17343.2	14120.8	177.94	1769.1	211.4	88.19	177	33710.7	34395	0.98	[12]
	Northeastern University	16849.2	5405.7	1422.4	490.5	489.4	19.3	110	24786.9	26369	0.94	[10]
General Under-graduate	Shenyang University	9316.8	6458.7	828.1	359.5	163.1	2.3	90	17218.1	21523	0.8	[10]
	Liaoning University	8022.21	2434.41	790.86	305.42	240.3	10.97	58	11862.1	10053	1.18	[11]
	Shenyang University of Technology	5913.41	830.48	340.13	389.54	103.8	3.26	31	7611.64	3107	2.45	[10]
	Chizhou College	4748.4	2573.9	425.5	257.3	189.1	107.1	54	8301.2	4800	1.73	[13]
	Shandong University of Science and Technology	8347.5	6665.8	1516.8	704.32	563.5	17.5	243	18058.4	40000	0.44	

(2) From the structure of the ecological footprint, in Shandong University of Science and Technology, the proportion of energy footprint is similar to the proportion of food footprint, which is similar to Peking University. However, compared with other universities, the proportion of energy ecological footprint is lower.

(3) From the per-capita ecological footprint, the per-capita ecological footprint of Shandong University of Science and Technology is much lower than that of other universities. According to the definition of the campus ecological efficiency, the smaller the ecological footprint, the more the number of students in the unit ecological footprint, thus the number of carrying students in ecological footprint of Shandong University of Science and Technology is large and the carrying capacity is great.

5. Conclusions and Recommendations

5.1. Conclusion

(1) The ecological footprint of Shandong University of Science and Technology in 2016 was about 18,058.46hm^2, and the ecological efficiency was 2.22person·hm^{-2}, that is to say, 1hm^2 eco-productive land at least needs to support the cultivation of two students to consume and absorb the waste generated. The school's ecological footprint mainly comes from food, heat, electricity consumption and waste emissions, accounting for 90.6% of the total footprint. Therefore, the construction of "green campus" should start with improving the energy structure, adopting effective measures to save energy and reducing waste emissions.

(2) From the calculation of ecological efficiency, we can see that the ecological efficiency of Shandong University of Science and Technology is on the high side, which makes the output efficiency of the talents of Shandong University of Science and Technology higher, but too high efficiency will lower the quality of personnel. How to ensure to cultivate efficiently high-quality personnel should be an important aspect of the future discipline construction.

(3) By comparing with the ecological footprint of universities at home and abroad, we can conclude that the energy ecological structure of Shandong University of Science and Technology is at a healthy level; compared with the first-class universities of the similar scale, the total ecological footprint of Shandong University of Science and Technology is lower, and the ecological efficiency is great, and the ecological footprint of per capita is less; in the ecological footprint structure, the proportion of energy and food ecological footprint is similar, which is mainly related to the scale of the school. Shandong University of Science and Technology covers a large area and has a number of students in school. coupled with the recent years, Shandong University of Science and Technology continue to discipline construction, student enrolment, Increase the size of the school staff, daily energy food consumption higher, but from the per capita ecological footprint is too small can be seen, Shandong University of Science and Technology service facilities to increase the pace of slow, so we need to strengthen the construction of service facilities.

(4) In the process of data collection and collation, we don’t guarantee absolutely the integrity of data of an area. On the one hand, the influence of external energy inflows, such as food affected by off-campus shops; on the other hand, there is a lack of statistical data, such as calculating traffic mileage ignoring the mileage of mobile in a small range, the amount of garbage calculation just calculating the garbage centralized processing. Therefore, it leads to a low computational result. In addition, the main drawback of the ecological footprint is the inability of the Ecological Footprint to track the human-induced depletion of natural capital stocks [25], which is a static method. And the component method covers a large range. We can refined the level further, clear the distinction between the use of stocks and the use of flows in order to make the calculation results achieve higher accuracy and reliability so that a systemic calculation method to promote the promotion of ecological footprint in the national university campus can be formed.

5.2. Recommendations

By analyzing the structure of the ecological footprint of Shandong University of Science and Technology and combining with the characteristics of comparison with domestic and foreign universities, it is concluded that Shandong University of Science and Technology is in a state of carrying capacity relatively saturated, high ecological consumption and low efficiency of talent construction. In this regard, we provide the following suggestions:

(1) Optimize the campus structure. Shandong University of Science and Technology has a large scale of construction, construction area of 1.45 million square meters, accounting for about half of the campus area with 40,000 students, from the ecological footprint calculation results can be seen that the per capita ecological footprint is too small; the school capacity is relatively saturated. By optimizing the structure of the campus, the rational use of land functions, increase space utilization, improve per capita ecological footprint, and reduce the burden on schools.

(2) Advocate energy-saving emission reduction; improving the rate of resource utilization. We should improve energy structure, adopt effective measures to save energy and reduce waste emissions.

Under the guidance of low-carbon theory, we should improve the utilization of resources and promote the recycling of material energy. Actively using solar energy, geothermal energy and other new energy sources in campus lighting, bathroom heating; strengthen energy-saving emission reduction, through reducing private cars, the use of "step on behalf of the car", "riding a bicycle-sharing " and other ways to reduce traffic ecological footprint; Making measures in heating, steam boiler room and catering kitchen equipment to reduce emission, by evaluating the equipment usage cycle, reducing the discharge of laboratory waste disposal and encouraging campus waste recycling and reuse of water etc to create "green campus".

(3) Formulate a reasonable plan for talent training. Provide equal opportunities for development, encourage students to actively carry out scientific and technological innovation, and improve the quality of students; strengthen the construction of service facilities; provide students with better learning platform and cognitive channels.

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