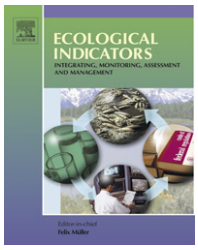
available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/ecolind



Application of the componential method for ecological footprint calculation of a Chinese university campus

G.J. Li *, Q. Wang, X.W. Gu, J.X. Liu, Y. Ding, G.Y. Liang*

Resources and Ecological Economics Research Center, Northeastern University, Shenyang 110004, China

ARTICLE INFO

Article history:
Received 6 September 2006
Received in revised form
9 January 2007
Accepted 12 January 2007

Keywords:
Campus
Ecological footprint
Energy
Hectare

ABSTRACT

The componential method of ecological footprint is applied to estimate the ecological footprint of Northeastern University (NEU) in 2003. The components considered in this study include energy (coal, natural gas, and electricity) consumption, food consumption, waste disposal, water supply, transportation, and paper consumption. The ecological footprint of NEU was 24,787 ha, meaning that nearly 25,000 ha of ecologically productive lands were needed to support consumptions and wastes disposal. The largest component of ecological footprint was energy consumption, which took up 68% of the total footprint; the second and the third largest footprint components were food consumption and waste disposal. In a word, ecological footprint can serve as a practical and meaningful tool for comparing and monitoring the environmental impact of campuses.

1. Introduction

The ecological footprint is a comprehensible indicator that can show very clearly the effects of society's action on environment (Rees, 1992). Wackernagel and Rees initiated the development of this method in the mid-1990. The ecological footprint estimates the "minimum land necessary to provide the basic energy and material flows required by the economy" (Wackernagel and Rees, 1996). The ecological footprint analysis used is based on the concept of appropriated carrying capacity, defined as the amount of land required to supply the necessary resources and assimilate the outgoing waste at the current human population. Since published in 1992, because of its notional visualization, easily understood and calculated, the ecological footprint was attended broadly by a lot of researchers.

The research mostly applies the approach in three different settings:

(1) Nations

World Wildlife Fund for Nature (WWF) published the "Living Planet Report 1999, 2000, 2002, and 2004". In the reports, many countries' ecological footprints were calculated, especially, WWF calculated some important countries' ecological footprint from 1961 to 1999 (WWF, 1999, 2000, 2002, 2004). In "Ecological footprint of Nations", Wackernagel calculated 52 countries' ecological footprint (Wackernagel and Rees, 1996), while Van Vuuren and Smeets calculated and analyzed the ecological footprint of Benin, Costa Rica, Holland and Bhutan (Van Vuuren and Smeets, 2000).

(2) Districts and cities

Folke et al. gave the ecological footprint results of 29 cities in the area of European Baltic Sea (Folke et al., 1997); ecological footprint of London, Liverpool and York had been researched by best foot forward (BFF) (Chambers et al., 2002) and Stockholm Environment Institute (SEI) (Barrett et al., 2001, 2003).

(3) Enterprises, school, family and industry

Stockholm Environment Institute (SEI) analyzed the different families' ecological footprint in York (Barrett et al., 2001); He et al. got the ecological footprint and ecological rucksacks of cars (He et al., 2005); Yang et al. estimated the ecological footprint of tour (Yang et al., 2005).

* Corresponding author. Tel.: +86 24 83678400; fax: +86 24 83680388.
E-mail address: neulgj@gmail.com (G.J. Li).
1470-160X/$ – see front matter
doi:10.1016/j.ecolind.2007.01.007

Table 1 – Consumption and waste at the Northeastern University

Component	Total
Energy	
Electricity	18,400,000,000 kWh
Coal	32,925 t
Nature gas	129,000 ft^3
Water	3,300,000 ft^3
Waste discard	
Paper and textiles	713.84 t
Garden and park waste and other (non-food)	1,500 t
Food waste	1,581.65 t
Glass waste	18.66 t
Plastic waste	685.85 t
Traffic	
Car	349,197 km
Truck	40,137 km
Food	
Non-beeves, non-mutton	111,606 kg
Cereals	1,288,487 kg
Fruit	276,901 kg
Sugar	37,541 kg
Vegetable	1,690,542 kg
Eggs	207,016 kg
Pulses	162,713 kg
Beeves, mutton	55,913 kg
Milk	7,075 kg
Marine fish	45,483 kg
Paper	244 t
Campus area	110 ha

In order to assess the environmental impact of a university campus, this paper uses the ecological footprint analysis (EFA). This method attempts to account for the different facets of a specific individual, institutional, or regional environmental impact. It incorporates basic lifecycle data for energy demand (coal, oil, nature gas and electricity), material consumption (food, water, paper and manufactured goods), waste and transportation.

2. Calculation of ecological footprint

2.1. *Data collection*

The data of the electricity consumption, nature gas consumption, coal consumption, water consumption, food consumption and waste discard were obtained directly from logistic management office of NEU; the data of transportation, paper consumption and the components of waste were obtained indirectly from the questionnaires. The data of consumption and waste are following Table 1.

2.2. *Result of ecological footprint*

According to the calculational method of ecological footprint, this paper calculated the ecological footprint of NEU. The results of ecological footprint for NEU are following Table 2.

Table 2 – Consumption and waste at the Northeastern University

Component	EF (ha)
Energy	16849.2
Electricity	3343.6
Coal	13477.7
Nature gas	27.9
Water	489.4
Waste discard	1422.9
Paper and textiles	195.8
Garden and park waste and other (non-food)	175.3
Food waste	162.9
Glass waste	35.5
Plastic waste	853.4
Traffic	19.3
Car	13.8
Truck	5.6
Food	5405.7
Non-beeves, non-mutton	1508.2
Cereals	418.7
Fruit	29.0
Sugar	2.1
Vegetable	100.4
Eggs	517.5
Pulses	87.7
Beeves, mutton	1694.3
Milk	14.1
Marine fish	1033.7
Paper	490.5
Campus area	110

3. Analysis of ecological footprint

3.1. *Ecological footprint of NEU*

In the ecological footprint of campus of NEU (Table 2), the largest component was the ecological footprint of energy, accounting for 67.97% of the total ecological footprint, next is the ecological footprint of food, the ecological footprint of traffic is the least. Situated in the north of China (Fig. 1), winter being cold and long, each year NEU needs many tonnes of coal for heating, so it is easy to see the ecological footprint relates the climate. The ecological footprint of food is approximate 50 times campus' area, however, an average of 5 t of waste food was produced each day. A reduction of this, in combination with a more clear focus at NEU regarding saving food, could reduce the impact on the environment of the food-based activities. In connection with the investigation of waste it became clear that only a small part of the waste material was recycled. An important reduction of the waste based footprint could be made through a clearer focus among students and staff on recycling waste materials. The ecological footprint of traffic was the smallest components in the total ecological footprint. With the improvement of the standard of Chinese living in the future, however, there will be more and more cars driven on campus similar to what has happened in the developed countries, and consequently the impact of traffic can be expected to be strengthened.

Fig. 1 – The situation of NEU in China.

3.2. *Comparing with other universities*

It is easy to see from Table 3 that the largest component of the ecological footprint in Northeastern University, Colorado College and Redlands University was energy. But Colorado College and Redlands University did not use coal (direct energy), they mostly used electricity (indirect energy). In particular, the ecological footprint proportion of electricity in Colorado College was very large, accounting for 80%, while Northeastern University and Redlands University were 13.49% and 31.4%, respectively. The ecological footprint proportion generated by traffic was large in Redlands University, with 32.46%, while Northeastern University and Colorado College were only 0.08% and 1.4%, respectively. The ecological footprint proportion from food in Colorado College and Redlands University was lower than that in Northeastern

Table 3 – Ecological footprint of NEU compared with other universities

Component	Northeastern University		Colorado College		Redlands University	
	EF (ha)	Total EF (%)	EF (ha)	Total EF (%)	EF (ha)	Total EF (%)
Coal	13477.7	54.37				
Electricity	3343.6	13.49	4463	80	724.7	31.4
Nature gas	27.9	0.11	395	7	431.2	18.68
Food	5405.7	21.81	574.1	10	113.4	5
Waste	1422.9	5.74			289.5	12.46
Paper	490.5	1.98				
Water	489.4	1.97	56.5	1		
Campus area	110	0.44	36	0.6		
Traffic	19.3	0.08	78	1.4	749.0	32.46
Total	24786.9	100	5602.6	100	2307.7	100

University, which indicates a clear impact of the standard of living on the ecological footprint of the campus.

4. Conclusions

This paper uses the componential method of ecological footprint to calculate the ecological footprint of NEU's campus and analyze the different components of NEU's ecological footprint. There were 23,345 students in 2003 in NEU, the total ecological footprints were 24786.9 ha, and the average consumption of one student was 1.06 ha. The dominating components of NEU's ecological footprint were energy, food, and waste, the sum of which accounted for 95% of the total ecological footprint, so the measures of reducing the ecological footprint of NEU should be aimed at these components in future. Based on the above results and analyses, the following recommendations may be made for consideration in NEU, aiming at a more sustainable future:

(1) Energy consumption is the largest source of ecological footprint, so raising energy efficiency and changing energy structure should, therefore, play a vital role in the development of NEU.
(2) More emphasis should be put on renewable energy resources at the NEU. It is said that using the geothermal resources for heating could save 1/3 of the present coal consumption, but at the NEU only the natatorium used the geothermal resources, so the exploitation of geothermal resources should be extended in next years.
(3) The ordinary lamps should be replaced by energy-saving ones; the streetlights should be opened half in midnight; the running computers should be closed when they are not in use.
(4) NEU should organize periodic environment protective campaigns to raise students' environmental awareness; NEU should also let more and more students attach themselves to NEU's management and give their advices for NEU's development.

Acknowledgements

The vice present of Prof. Wanshan Wang, NEU, the assistant of present of Prof. Yiqiu Wang, NEU, afforded much help to us for this research; at the same time, the different departments of NEU also supplied much convenience to us. We thank all the people for this research.

REFERENCES

Folke, C., Jansson, A., Larsson, J., et al., 1997. Eco system appropriation by cities [J]. Ambio 26 (3), 167–172.
He, Y.H., Liu, Y.Z., Jiang, L., 2005. On the ecological rucksack and footprint of car's entering into families [J]. Ecol. Econ. 12, 57–60.
Barrett, J., Scott, A., Lindfield, S., 2001. Ecological Footprint of Liverpool: Developing Sustainable Scenarios [R]. York, Stockholm Environment Institute, pp. 1–121.
Barrett, J., Vallack, H., Jones, A., et al., 2003. A Material Flow Analysis and Ecological Footprint of York [R]. York, Stockholm Environment Institute, pp. 1–9.
Chambers, N., Heap, R., Jenkin, N., et al., 2002. A Resource Flow and Ecological Footprint Analysis of Greater London [R]. Best Foot Forward Ltd., Oxford, pp. 1–72.
Rees, W., 1992. Ecological footprint and appropriated carrying capacity: what urban economics leaves out [J]. Environ. Urban. 4 (2), 121–130.
Van Vuuren, D.P., Smeets, E.M.W., 2000. Ecological footprints of Benin, Bhutan. Costa Rica and the Netherlands [J] Ecol. Econ. 34, 115–130.
Wackernagel, M., Rees, W., 1996. Our Ecological Footprint: Reducing Human Impact on the earth [M]. New Society Publishers, Gabriela Island, pp. 1–215.
WWF, the Global Conservation Organization. Living Planet Report 1999, Living Planet Report 2000, Living Planet Report 2002 and Living Planet Report 2004. http://www.panda.org.
Yang, G., Li, P., 2005. Touristic ecological footprint: a new yardstick to assess sustainability of tourism [J]. Acta Ecol. Sin. 25 (6), 1475–1480.