2-4 Developing Indicators to Establish a Sound Material-cycle Society: China's Ecological Deficit as Inferred from Ecological Footprint Analysis

Takehito Ujihara[1], Hirofumi Abe[2]

[1] *Solid Waste Management Research Center, Okayama University, Japan*
[2] *Graduate School of Environmental Science, Okayama University, Japan*

Abstract

This report proposes specific policies and indicators for use in the establishment of a sound material-cycle society. In fiscal 2010, the study explained herein was applied to evaluate the ecological footprint (EF) of China, which includes economically developed and developing regions.

The results of analyses are the following.

1) China has been in ecological deficit (overshoot) from an environmental standpoint.
2) The per-capita ecological deficits are greater in eastern China. The regional gaps between the eastern areas and the middle southern areas in China are not slight. However, no „ecological reserve" region exists.
3) In western areas, results show that the environmental capacity exceeds EF in many regions.

1. Introduction

Responses to global warming and waste problems are urgent tasks for all humanity. The establishment of a sound material-cycle society is one solution for them. Various approaches have been attempted to establish a sound material-cycle society. Environmental evaluation indicators of such a society have been reported as greenhouse gas emissions and the rate of cyclical use of resources. However, such indicators are insufficient.

An environmental indicator called the Ecological Footprint (EF), which has been used recently, has attracted great interest (Wackernagel, M. and W. Rees, 1996). The synthetic EF indicator can indicate different environmental loads such as CO_2 emissions, food consumption, and natural resources consumption by calculations made in terms of the area of land consumption. This indicator can reflect the relation between an area's environmental loading and environmental capacity such as forests ands farmlands. It also supports estimation of the environmental balance and Ecological deficit (overshoot) (Global Footprint Network, 2010). Therefore, it is expected to become a useful environmental evaluation indicator for the establishment of a sound material-cycle society. Moreover, the EF can be shared to provide a common illustration of environmental issues, thereby enabling understanding environmental loading intuitively. In other words, the indicator can serve a key role as a communication tool to promote "Practical Research and Education of Solid Waste management Based on Partnership between Universities and Governments in Asia and Pacific Countries."

This study was undertaken to propose specific policies and develop indicators for the establishment of a sound material-cycle society. China, which was selected as the target area of this fiscal year, consists of developed and developing areas, all of which have diverse characteristics. Consequently, its interregional gaps are stark. In other words, it might be appropriate to examine

China specifically in our attempt to understand the correlation between economic growth and environmental loads.

Research of this fiscal year was undertaken to calculate the regional ecological footprint of China, and to ascertain the prevailing environmental loading in China, overshoot, and interregional gaps.

2. Methods

(1) EF value calculation

The EF used in this research consists of the following components.

EF1: Forestland to absorb CO_2
EF2: Farmland to grow crops for food and feed
EF3: Forestland to obtain wood material
EF4: Grazing land to graze livestock for meat and milk
EF5: Built-up land to support urban activities

The method of calculation of the EF value is based on a Eq. (1) proposed by Wackernagel[1]. The main data used for calculations are shown in Table 1. Tibet is excluded from this calculation because of the lack of sufficient data.

$$EF_p = \sum_{l=1}^{n} \frac{C_l}{P_l} \quad (1)$$

EF_p: Per-capita ecological footprint (ha/person)
C_l: Consumption per capita of consumption goods „l“(t/person)
P_l: Production per unit of consumption goods „l“(t/ha)

Regarding „farmland“, „built-up land“, and „forestland“, this calculation uses data that reflect regional characteristics. However, regarding „grazing land“ and „forestland“, this calculation employs the average consumption volume per Chinese citizen. Regarding the data-use issue, it is necessary to improve the conditions by reinforcing the database.

Table 1 Main data used for calculations

EF	Components in the EF indicator		Data for calculation
1	Farmland to grow crops for food and feed	Food	Consumption of grain, vegetables, and fruits etc. per person in each region[3]
		Feed	Consumption of pork, beef, and poultry etc. per person in each region[3]
2	Grazing land to graze livestock for meat and milk		Average consumption per Chinese citizen measured by Global Footprint Network[2]
3	Forestland to obtain wood materials		
4	Built-up land to support urban activities		Area of urban land use in each region[3]
5	Forestland to absorb CO_2 from fossil fuels		CO_2 emissions in each region[4]

3) National Bureau of Statistics of China, 2010
4) Shimizu, M., 2010

(2) Methods of calculating the environmental load excess ratio and ecological deficit

The environmental load excess ratio indicates the environmental balance based on EF and environmental capacity (EC). The indicator in region „*i*“ (r_i) is defined as follows. The EC is expressed as the area of land necessary to absorb each component in the EF, such as the actual farmland area in a target region.

$$\gamma_i = \frac{EF_i}{EC_i} \tag{2}$$

EF_i: EF in region „*i*“ (ha)
EC_i: Environmental capacity (EC) in region „*i*“ (ha)

However, that does not mean that all regions must seek an environmental load ratio in excess of „1.0“. It is important to become aware of the environmental balance in a region. The indicator can quantify environmental balance.

The ecological deficit in region „*i*“ (r_i) is defined as follows. The indicator represents the overshoot (Ecological deficit[2)]) by which the environmental capacity per person in China is subtracted from the ecological footprint per person in each region.

$$d_i = EF_{ip} - EC_p \tag{3}$$

EF_{ip}: Per-capita EF in region „*i*“ (ha/person)
EC_p: Environmental capacity per Chinese citizen (ha/person)

3. Results

1) The ecological footprint of China is about 12 hundred million hectares. Its environmental capacity is about 8 hundred million hectares. Results clarify that China has an Ecological deficit of about 4 hundred million hectares.
2) Figure 1 shows that the amounts of ecological deficit per person are larger in the eastern parts of China, especially in northeastern areas. It can also be interpreted that the environmental differences between eastern areas and the middle south areas in China is not slight. However, no „ecologically reserved region“ exists in which the amount of the environmental capacity per person exceeds the amount of ecological deficit.
3) Figure 2 shows that, in China, the coastal areas are the „source areas“; the „sink areas“ exist surrounding the „source areas“. Especially, Beijing and Shanghai are typical cities of the „sink area“. In „Inner Mongolia“, the amount of the ecological footprint per person is extremely large, but it also has environmental capacity which greatly exceeds that within its area. In addition, Sichuan Province has a great amount of the environmental capacity, but some areas have a small ecological footprint per person.

4. Future Perspective

Our project team will continue to study the relations among regions“ ecological footprints and economic indicators.

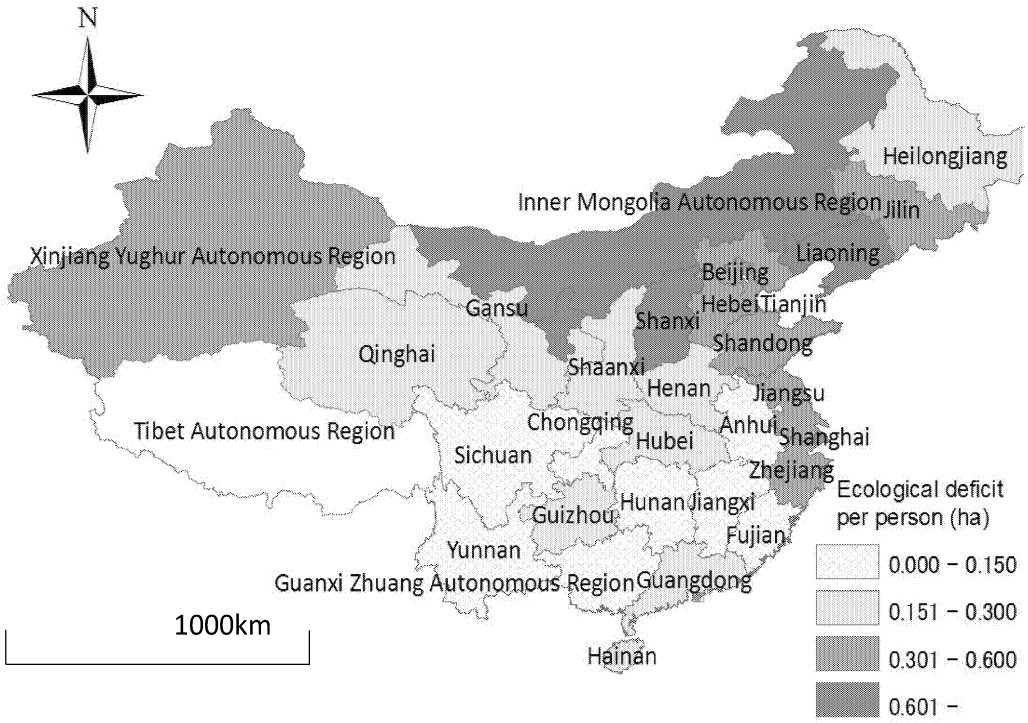

Figure 1 Per-capita ecological deficits in respective regions.

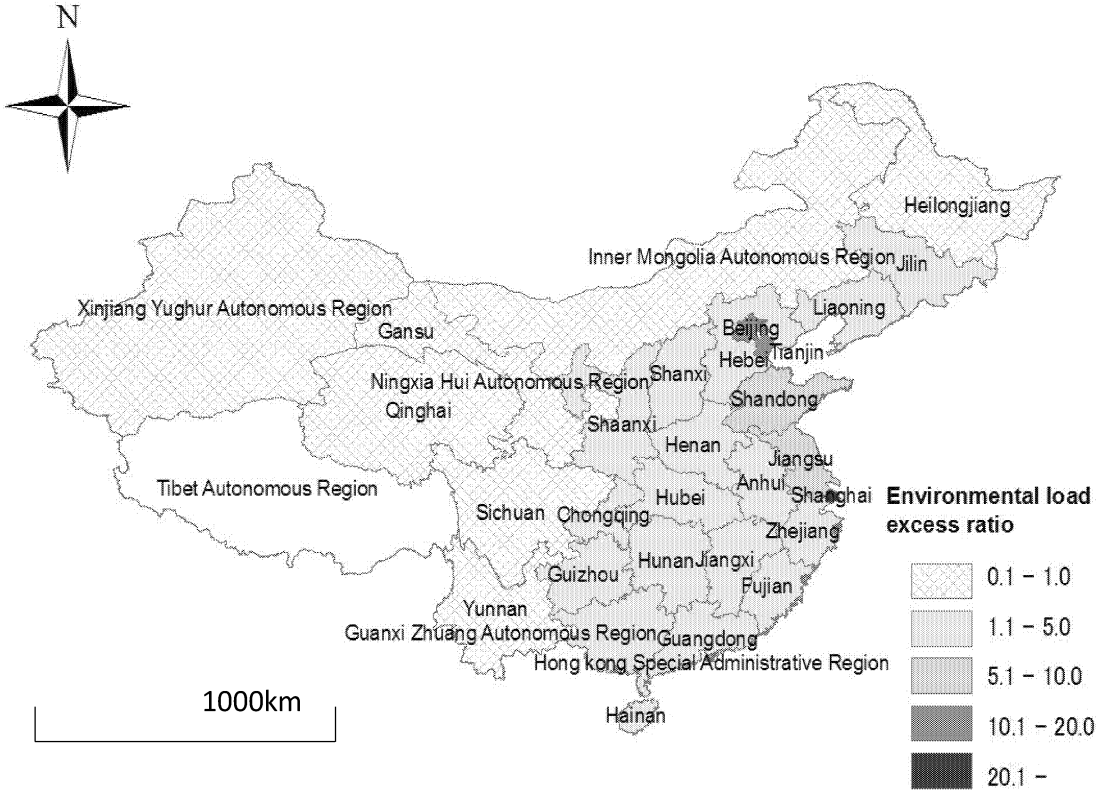

Figure 2 Environmental load excess ratios in respective regions.

References

1) Wackernagel, M. and W. Rees, *Our ecological footprint Reducing Human Impact on the earth*, New Society Publishers (1996).
2) Global Footprint Network, *Ecological footprint and biocapacity 2007, National Footprint Accounts (2010).*
3) National Bureau of Statistics of China, *China Statistical Yearbook* (2010).
4) Shimizu, M., Estimates and discussions about SO_2, NO_x and CO_2 emissions by industry and region in China, The 69th Annual Meeting of the Japan Society International Economics (2010) (in Japanese).