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The impact of human behavior on ecological threshold: Positive or negative?—Grey relational analysis of ecological footprint, energy consumption and environmental protection

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HIGHLIGHTS

- We demonstrate the interaction between ecosystem and behavior system by grey analysis.
- We calculate the grey correlation coefficients between ECEI, ECEC and EEF in Shanghai.
- Electricity is the key indicator to energy consumption and environmental protection.
- Negative behavior has more significant impact on ecosystem than positive behavior.
- Reducing the negative activities is imminent in the current process of development

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ABSTRACT

Human behavior has the positive and negative impact on ecosystem. To study the interaction between ecosystem and behavior system, per-capita energy ecological footprint (EEF) is selected as the ecosystem threshold. Elasticity coefficient of environmental investment (ECEI) and elasticity coefficient of energy consumption (ECEC) represent the positive and negative human impact on ecosystem, respectively. It takes Shanghai, China as the empirical area to implement grey relational analysis of per-capita EEF (consist of coal, coke, fuel oil, and electricity), ECEC and ECEI from 1978 to 2010. The grey correlation coefficients show that negative behavior of energy consumption has the closer influence on the ecosystem than positive behavior of environmental protection. Electricity is the most significant factor of the energy consumption and the highest sensitive indicator to the environmental capital input–output. From the perspective of government policy, "energy saving" is more efficient than "emission reduction". Reducing the negative activities is imminent in the current process of development.

1. Introduction

1.1. Pollution

In May 2007, a large area of blue–green algae accumulated in Taihu Lake of China broke out. Blue–green algae went through the water pipe into the millions of households, resulting in a public drinking water crisis, more than two million people in Wuxi have been disrupted the normal order of life. Phase I treatment project of Taihu Lake completed earlier has invested 10 billion Yuan, Phase II is expected to invest 100 billion Yuan. Though a huge capital has been invested, the output efficiency is questionable.

1.2. Damage

The United Nations estimates that sea levels will rise 58 cm by 2100, due to ozone destruction caused by global warming. Maldives composed of the 1200 islands and coral reefs is facing with the threat of disappearance of any time. President Mohamed • Nasheed of Maldives has prepared some income from domestic tourism earmarked "Land Purchase Fund" to accommodate the resulting large number of "environmental refugees" (The British newspaper of "The Guardian" reported it in November 10, 2008).

1.3. Waste

According to the "Waste and Resources Action Project" supported by the Department for Environment, Food and Rural Affairs (DEFRA), the UK throws away "junk" food 17 million tons

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each year, accounting for purchases of 1/3, with the value of 8 billion to 20 billion pounds. The 25% of so-called "junk" thrown away each year in the world is safe and harmless, at least to feed 70 million people. Inappropriate behavior of over purchase, improper storage and eclipse picky eaters are three main reasons for food wasting.

From the above examples, both in developed and developing countries, there are a lot of environmental pollution and resource destruction behavior generated by economic benefits and waste behavior caused by consumption habits. The fundamental reason is that the mode and the strength of the human impacting upon the environment do not take "the natural law" as a precondition, but rather to their own values. In the production and consumption process, people abuse ecological resources free but limited out of control, then as much as possible to save the resources needing to pay.

2. The relationship between ecosystem and human behavior

The latest researches fully pay attention to illustrate the significant correlation between natural resources and human impact. The International Human Dimensions Programme on global environmental change (Jager, 2003) proposes that the world-wide changes are rooted in human activities, highly concerned about social security issues caused by globalization. Adjusting human activities is more practical than regulating the natural factors of ecosystem (Petrosillo and Zaccarelli, 2009). By reasonable arrangement and orderly organization of human activities, it can be predicted that the living environment in general does not significantly degrade, even continue to improve (Huang and Qin, 2009). Sustainable development is a multi-dimensional and multidisciplinary concept that has been emerged from a number of disciplines, including economics, ecology, ethics, sociology and political sciences. It focuses on a specific framework for economic environment integration with emphasis on the "social" component (Mossalanejad, 2011). Human society must be as attuned as possible to their local and regional environments, their geo-ecological support systems. Lifestyles must be adapted to the ecosystems in which societies live and support them with cultures, practices, economic systems, and governing policies each adjusted to fitting their area (Reitan, 2005). Recently developed modules in GRASS GIS combine a wide variety of spatial data such as climatic, geological, and cultural in order to estimate how long-term interactions among these factors contribute to the evolution of natural environment and anthropogenic landscapes (Arikan, 2012).

However, the significant role of the self-constraints of human behavior on the ecological threshold is often ignored. In fact, the effect of overcoming a difficult technical bottleneck (in 2007, 23.5 billion Yuan of China's fiscal expenditure was invested to support the energy-saving technological transformation projects of enterprises.) can be obtained by reducing a waste behavior. Similarly, if humans continue the laissez-faire way of extensive production and life mode, no amount of new energies and technologies can save the earth "disappearing" day by day. Human behaviors are usually driven by economic profit. Then, ecological problems are always in the process of balance, conflict and re-balance, decided by the structure of the community interests. Therefore, although the actors of economic and social development are humans, whose impacts on environment are directly expressed, the ultimate bearers are still human beings.

Human beings and ecological system are conjugate. The population and economy have exponentially grown to affect climate, ecosystem processes, and biodiversity far exceeding any other species. Like all organisms, humans are subject to natural laws and are limited by energy and other resources. It also plays a role in the ecosystem threshold changes. Without man-made interference, the eco-system carrying capacity is stable because of its self-correction and homeostatic mechanism. Once the disturbance exceeding the ecosystem threshold, it will turn to another steady state, and the carrying capacity will also change. The 2011 climate conference in Durban, South Africa, not only discussed whether the global warming has been into the plight of disorder, but also released the clear signal that environmental protection has deepened from a regionally structural adjustment to the globally political game. The conference marks for a major turning point of the studies from the prevention and alleviation of the impact of human activities on the environment, to study how to adapt to the environmental changes.

In this paper, we attempt to propose the issue that constraint of human behavior is the active and effective way to improve the resilience of the social-ecological system, to adapt to the global environmental changes, and to promote ecosystem restoration or the development to senior status, which provides a long-term mechanism for the realization of the eco-system security. We will study the human effect on the natural threshold, clarify their interaction, and discuss two basic questions. (1) Do the interaction relationships between human behavior and ecological thresholds exist? (2) Which is the key factor to improve the ecosystem sustainability, the direct result of reducing negative behaviors (e.g., saving energy consumption) or the indirect response of increasing positive behaviors (e.g., raising investment of environmental protection)?.

3. Literature review and indicators

3.1. Measurement of ecosystem threshold

The measurement and evaluation of the ecosystem threshold are the current research focus and the key scientific issues of the ecology. Emergy evaluation (Odum and Peterson, 1996), life cycle analysis (SETAC, 2008), the value of ecosystem services (Daily et al., 2009) and natural capital assessment (Costanza, 1996; Costanza et al., 1997) ecological footprint (Wackernagel et al., 2004), pressure-state-response (Levrel et al., 2009) and environmental sustainability index (Cui et al., 2004) are popular measurement methods. The above methods vary from energy flow, information flow, logistics, capital flow, as well as time and space to study the ecosystem processes under the influence of human activities. Different focus and standards of those measurements make the results difficult to compare and transform. Therefore, the precise values of ecosystem thresholds cannot yet really be obtained. However, all researches show the enormous pressure of the global ecosystem. The ecological security is seriously threatened.

3.2. Per-capita EEF

As a method to measure the threshold of the natural capital (land and water), ecological footprint (EF) is a biophysical quantitative evaluation tool. It calculates biologically productive areas of maintaining personal, regional, national and global survival or absorbing human emissions of waste (Wackernagel et al., 2006). EF translates the human′s consumption of resources and energies into six main types of land (referring to the ecological capacity of land or water): fossil energy land, arable land, forest, pasture, built-up areas and sea, reveals the natural threshold for the continuing existence of human. Studies have shown the significant ecological deficit in China's densely populated areas. This method is deficient in the accounting of water resources, atmospheric composition, stability, and aesthetics service functions