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ANALYSIS

Ecosystem service value assessment for constructed wetlands: A case study in Hangzhou, China

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A B S T R A C T

Based on a comprehensive analysis of various classifications of natural resource values, we summarized an ecological economic value system of constructed wetland (CW) ecosystems for treating eutrophic water. Using the CW located at the Hangzhou Botanical Garden as an example, the contingent valuation method (CVM) and shadow project approach (SPA) were applied to estimate the economic values of CW system ecosystem services. The CVM estimated a value of 800,000 yuan (yuan: Chinese Currency, 7.6 yuan = 1 USD as of August, 2007) as the total economic value of the CW in a twenty year period. Meanwhile, the SPA calculated a value of 23.04 million yuan as the total economic value of the CW in a twenty year period. It is determined that compared to the CVM, the SPA provides a more approximate value of the true monetary value of the Hangzhou Botanical Garden CW. This study could fill the gap of knowledge and provide a benchmark when evaluating constructed ecosystem services and help policy makers to promote the development of constructed wetlands in China.

1. Introduction

Ecosystem services represent the benefits that people obtain directly or indirectly from ecosystems (Costanza et al., 1997; MA, 2003). Assessing the economic values of ecosystem services play various and important roles in linking human activity and natural systems. As a specific interdisciplinary field of practice, the remarkable work of Daily (1997) and Costanza et al. (1997) has made a breakthrough in ecosystem services valuation. To date, most recent studies (Alberini et al., 2005; He et al., 2005; Spash et al., in press; Hougner et al., 2006; Brander et al., 2007; Costanza et al., 2007; Sattout et al., 2007), however, still focus their attention on estimating the value of natural ecosystem services; only few (Bolund and Hunhammar, 1999; Tian and Cai, 2004; Shen et al., 2005) attempt to estimate the value of constructed (or artificial) ecosystem services. From our points of view, constructed ecosystem services are similar to natural ecosystem services in essence, however, differ in the following main aspects: 1) enhancement of certain services and decline of most other services in constructed ecosystems comparing to natural ecosystems (Foley et al., 2005). Like human-dominated ecosystems services and unlike natural ecosystems services, certain constructed ecosystems services are usually designed intentionally; 2) higher direct use values (e.g., food production, recreation) than indirect use values are usually estimated

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through constructed ecosystem services in comparison with natural ecosystem services. For instance, constructed greenhouse usually provides a remarkable direct use value (mainly food production), while a tiny indirect use value; 3) the assessment scale of constructed ecosystem services is explicit than natural ecosystem services, since boundaries of the constructed ecosystem are usually more distinct than the natural ecosystem.

The constructed wetland (CW), a typical constructed ecosystem, was initially developed approximately forty years ago in Europe and North America to exploit and improve the biodegradation ability of plants (Shutes, 2001). Possessing the advantages of low construction and operating costs as well as its ability to be used on its own or in combination with other systems, CW is especially suitable for small communities in developing countries where potential health benefits from pathogen removal are considerable (Cooper et al., 1996; Shutes, 2001).

In China, the first CW study for wastewater treatment was launched as early as the period of the "7th Five-Year Plan" (1986–1990) (Li and Zheng, 1993). The first reed bed wetland appeared in 1987 and the first full-scale CW emerged in 1990 (Ding and Shen, 2006). Since 1999, China has been making a great progress in the area of CW application, reaching a peak with 127 research reports in 2004 (Gao, 2006). The problem, however, that urban wastewater treatment rates operate at only 46% as of 2004 must now be addressed (white paper on China Environment Protection, 1996–2005). Most small towns in China today still release daily wastewater, with excessive amounts of eutrophic materials containing nitrogen and phosphorus, directly into water systems without treatment (Jin et al., 2005). This is one of the major causes of water pollution, especially eutrophication pollution, in China.

When it comes to the economic valuation of constructed ecosystems in China, few studies have been conducted up to this point. Tian and Cai (2004) evaluated ecosystem services of constructed landscapes in Beijing; however, their study merely referred to natural ecosystem data from Costanza et al. (1997) with some revision. Another attempt was conducted by Shen et al. (2005) to assess ecosystem services of a CW system in Shenyang. Unfortunately, their sample capacity was limited since they only applied seventy-nine survey results. What is worse, several obvious calculation fallacies were present when calculating discount value, which rendered their results highly suspect. From both ecological and socioeconomic perspective, it is therefore necessary and meaningful to establish more CWs in China and apply further and more thorough studies towards them.

In this paper, a successful case study applying a CW in China is presented. Hangzhou Botanical Garden pumped groundwater to refill an ornamental fishpond from the 1960s to 2000. This approach was not only costly (total actual cost was approximately 520,000 yuan yr^{-1} from 1991 to 2000), but seriously damaged the groundwater environment. A CW wastewater treatment system was established specially to solve the problem. The wastewater from the ornamental fishpond can now be reused and the groundwater resource is now protected. Furthermore, the water quality of Jade Spring located within the ornamental fishpond and the ornamental quality of the fishpond itself is improved now.

The objectives of this study are 1) to summarize an ecological economic value system of the CW ecosystem for treating eutrophic water; and 2) to estimate ecosystem services of the CW in Hangzhou Botanical Garden using economic valuation methods. Two main methods are selected from the direct and indirect aspects in order to achieve our purposes, respectively. The first one is the widely used and argued contingent valuation method (CVM) (Loomis and Walsh, 1997; Ahlheim, 1998; Bateman et al., 1999; Adjaye, 2000; Carson et al., 2001; Venkatachalam, 2004); The second one is the shadow project approach (SPA), an altered replacement cost (RC) approach which is widely applied to assess the value of an ecosystem service by how much it costs to replace or restore it after it has been damaged (Gosselink et al., 1974; Garrod and Willis, 1999; Spash, 2000; Hougner et al., 2006).

2. Basic theory and methods

2.1. *Ecological economic value system of CW ecosystem services*

The CW ecosystems provide many essential goods and services which contribute to human welfare, such as outflow water, gas regulation, groundwater recharge, habitat for diverse species, scientific and educational values (Fig. 1). Since the terms "value", "valuation" and "value system" have a range of meanings in different disciplines (Farber et al., 2002), no uniform definition for value system of ecosystem services is available. Based on a comprehensive analysis of various classifications of natural resource values (Arrow et al., 1993;

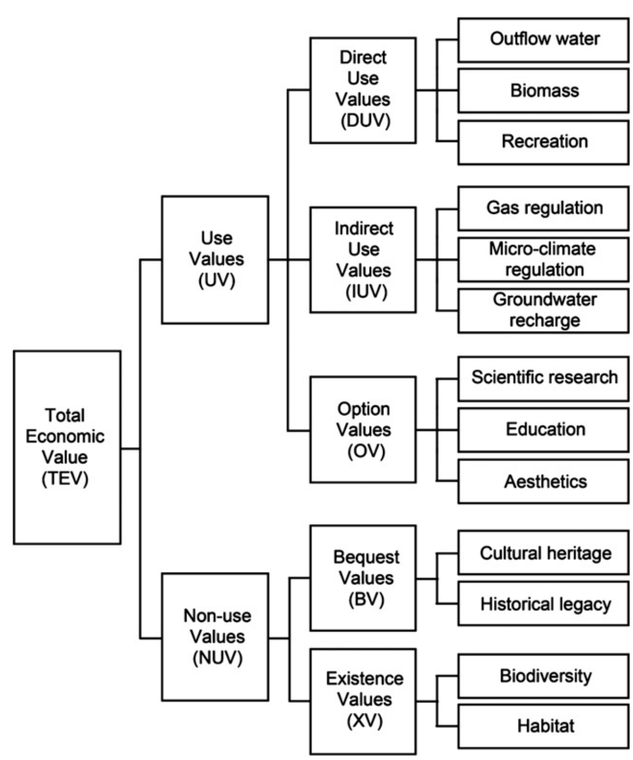

Fig. 1 – Ecological economic value system for the constructed wetland ecosystem treating eutrophic water.