available at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/ecolecon

ANALYSIS

A GIS-based approach for mapping direct use value of ecosystem services at a county scale: Management implications

Nengwang Chen, Huancheng Li, Lihong Wang*

Department of Environmental Science, Zhejiang University, Hangzhou 310028, PR China

ARTICLE DATA

Article history:
Received 19 August 2008
Received in revised form
29 November 2008
Accepted 4 December 2008
Available online 12 January 2009

Keywords:
Ecosystem services
Direct use value
Geographic Information System (GIS)
Valuation approach
Management implications

ABSTRACT

A GIS-based approach was designed to spatially estimate direct use value of ecosystem services and to map results for a case study at county scale. The approach highlights the use of GIS to collect data, perform spatial analysis, and map economic values of ecosystem services. Three key steps of spatial valuation for agricultural products, forest products, and tourism services were illustrated in the GIS-based technical framework. We applied this approach to the Tiantai County (1423.8 km^2) in Zhejiang province of southeast China. Selected components of natural products and tourism services in the case area were mapped as data layers in GIS, with each layer containing monetary values for every 25 m cell. The total direct use value of ecosystem services was estimated in RMB to be approximately 538 million Yuan in 2005 (Chinese currency, 8.2 Yuan=US$1), of which agricultural products, forest products and tourism services accounted for 65%, 30% and 5%, respectively. The critical areas for management purpose were identified depending on the heterogeneity of direct use services learned from the case study. The spatially explicit measures provide a mechanism for incorporating spatial context into ecosystem services evaluation. Based on the present GIS-based approach and case study, the suggestions and implications for local resources protection and eco-environmental management were extensively discussed. The work was expected to highlight research avenues to advance the ecosystem services framework as an operational basis for regional ecosystem-based management.

1. Introduction

The evaluation of ecosystem services has been one of the popular issues in ecological economics (Costanza et al., 1997; Daily et al., 2000), which aims to analyze and quantify the importance of ecosystems to human well-being to make better decisions regarding the sustainable use and management of ecosystem services. The evaluation of ecosystem services is also conducive to clarify and quantify the ecological and environmental changes. Ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well-being (Boyd and Banzhaf, 2007). The total ecosystem services value is a combination of direct use value, indirect use value, option value and existence value (see, among others, Pearce, 1991; Torras, 2000). A spatial economic valuation of various ecosystem services that demonstrates the value of ecosystem services to society and economy in monetary terms, undoubtedly provides vital information for regional ecosystem management and sustainable development. In recent years, approaches and methods for evaluating

* *Corresponding author*. Fax: +86 571 88273693.
E-mail address: nwchen@zju.edu.cn (N. Chen).

0921-8009/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.ecolecon.2008.12.001

ecosystem services were developed extensively in case studies representing a diversity of spatial scales and sites (Eade and Moran, 1996; Guo et al., 2001; Hein et al., 2006; Troy and Wilson, 2006; Egoh et al., 2008). However, little attention has been focused on the spatial visualization and mapping results for direct use value of ecosystem services (products or services derived from ecosystem and resources, discussed later). Previous economic valuations have been aspatial by estimating and describing direct use value with statistical data, such as production value, gross domestic product (GDP) for the whole region, which may be appropriate at macro level like national or provincial valuations. But for the county level, GDP measures only market economic activity or gross income (Costanza et al., 2001); it is never intended as a measure of economic welfare (Sutton and Costanza, 2002). Besides, the single numerical representation of products or services value is questionable for the spatially explicit purpose and difficult to combine with indirect use value (e.g. waste assimilation and nutrient regulation, freshwater regulation and supply, flood control), especially in hilly areas where natural resources and geographic features are highly heterogeneous. This situation hindered the efforts of the local governments and stakeholders to protect their resources and environment with limited funds and powers due to lack of space dimension about where is more urgent to be focused. A reasonable and easily-used methodology for spatially mapping ecosystem services value is very important in policy decisions. Despite the fact that indirect use versus direct use of ecosystem services seems continually increasing its fraction of total value. However, all over around the world, and especially in developing countries, and China, natural resources over-exploitation become the burning issue of the day. We firstly gather our efforts to develop a practical methodology for mapping direct use value with respect to resources heterogeneity. This methodology undoubtedly provides technical support for resources protection and ecosystem management.

Rauscher (1999) offered a review of decision support systems related to implementing ecosystem management and pointed out that the strategic goal of ecosystem management is to find a sensible middle ground between ensuring long-term protection of the environment while allowing an increasing population to use its natural resources for maintaining and improving human life. Most coastal counties in China, similar to other developing areas over around the world, have experienced rapid urbanization and population expansion in recent decades. The use and disposal of resources, however, are not matched by corresponding growth to meet those demands under traditional ecosystem management approaches while sustaining desired levels of environmental quality (Silver and DeFries, 1990). Continuous impacts on ecosystem services have occurred due to the significant changes in land use, but such effects are difficult to quantify. The economic values, as a result, often used as the surrogate or proxy for mapping the distribution of ecosystem services are thus hidden. The areas of rich natural resources with high economic value used as prior indicators for environmental quality suggests the critical management importance for ecosystem services, because variable economic value could not be simply expressed by single numerical representation. However, achieving the quantification of such critical areas over time requires considerable understanding of the ecosystem services, as well as their spatial distribution at county scale. The ecosystem management has come to rely strongly on the integrated analysis system to visualize and quantify the spatial variety of ecosystem services value.

In this paper, we presented an approach for the spatial visualization of direct use value of ecosystem services, illustrated through a case study of the Tiantai County in southeast China. Geographical Information Systems (GIS) was used as a helpful tool in data collection, spatial analysis and results mapping. This paper firstly defines the direct use services of an ecosystem and the required data for economic valuation. Secondly, it presents a technical framework and key steps for conducting spatial analysis and visualization of direct use value of ecosystem services by linking GIS, geospatial data, biophysical data and socio–economic data. Thirdly, it illustrates how this approach was applied to the case study. The present approach was discussed in terms of implication for future ecosystem-based management.

2. Methodologies

2.1. *Definitions of direct use value*

The value of ecosystem services depends upon the views and needs of stakeholders (Vermeulen and Koziell, 2002). Direct use values arise from human direct utilization of ecosystems (Pearce and Turner, 1990), for example, through the sale or consumption of a piece of fruit. All production services and some cultural services (such as recreation) have direct use value (Hein et al., 2006). As general view, the three types of direct use value of ecosystem services are discussed below.

(i) Agricultural products. Direct uses of agricultural products are associated with products derived from planting, animal feeding and fishery. They include the value of consumptive uses, such as harvesting of food products (e.g. grain, grape, sugar cane, cotton, tobacco, flower, melon, tea, orchard, and mulberry), and timber for fuel or construction after cultivation and deforestation. Animal feeding and fishery provide foods as meat and fish.

(ii) Forest products. They involve mainly timber value of living trees which has a potential market value, namely stumpage. The value depends on the density of dominant forest species and the relevant market price of various stumpages.

(iii) Tourism services. Rather than provide products, tourism services offer non-consumptive uses such as the enjoyment of recreational and cultural amenities like wildlife and bird watching, water sports, and spiritual and social services that do not require harvesting of products. Willingness to pay (WTP) for a particular natural attraction has been the most frequently used indicator for the economic value of the attraction (Tisdell, 2006). However, WTP data are always unavailable in most cases especially in China. Valuations of tourism services do not have a better value than entrance fees of a park although which may probably underestimate the real